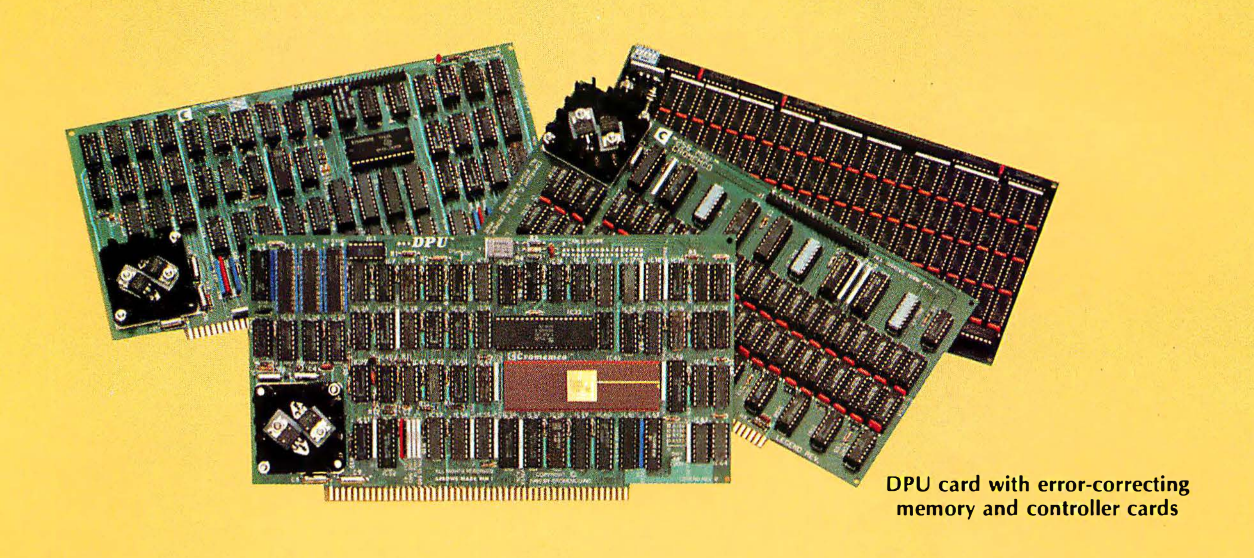

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FULL SCREEN
HIDETURTLE
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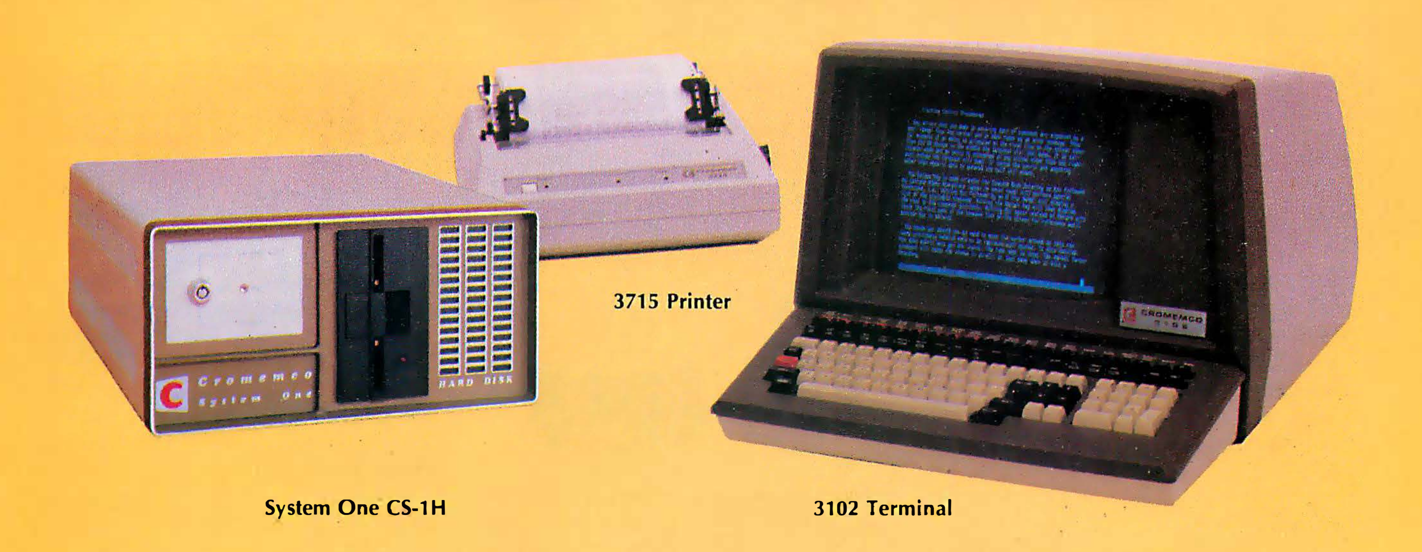
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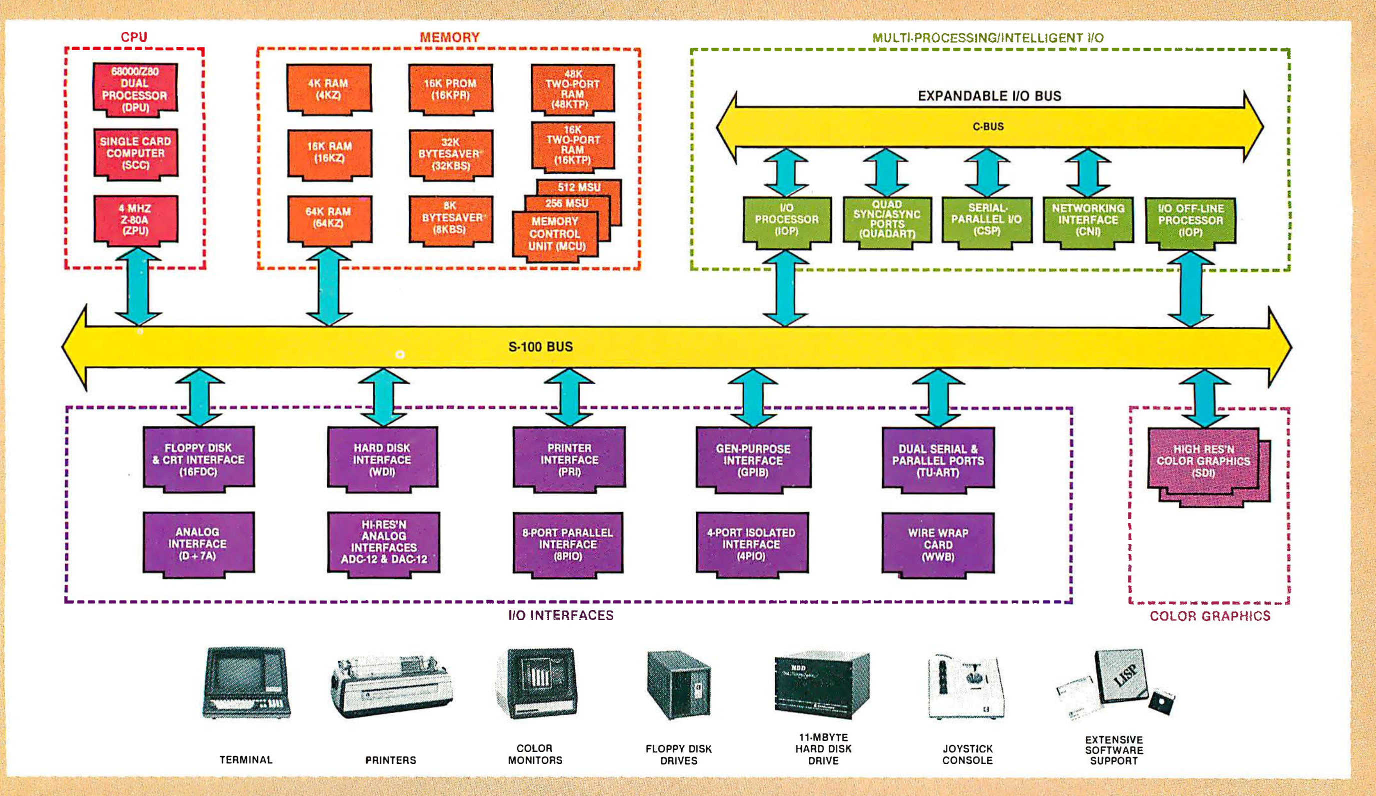
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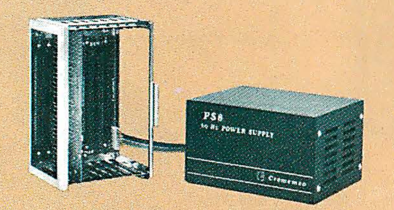
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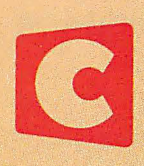
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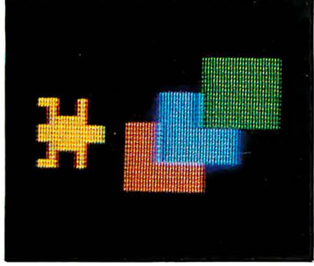
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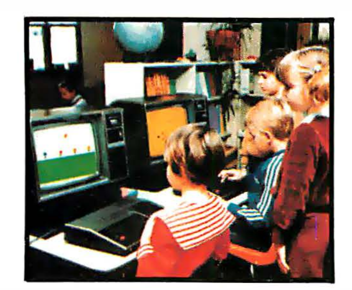
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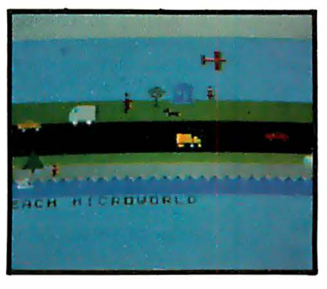
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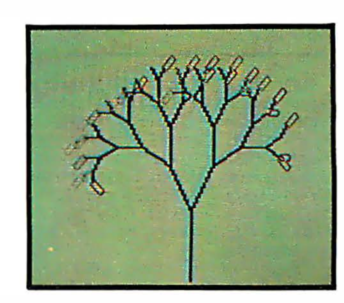
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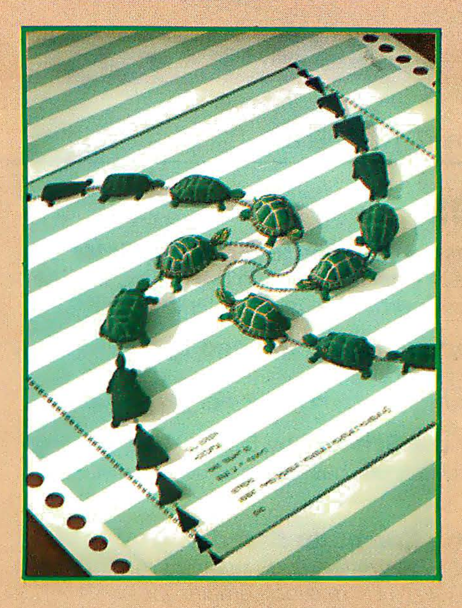

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In This Issue

Welcome to our annual language issue. This year we present Logo, the microcomputer language perhaps best known for its turtle graphics. Mathematically minded readers may recognize the cover illustration by Robert Tinney as BYTE's own version (influenced slightly by M.C. Escher) of the classic four-bug puzzle. In this puzzle, for which a Logo program is shown on the cover, four bugs are placed at each corner of a square; each bug attempts to walk toward the bug to its immediate right. In the process they trace Archimedean spirals. The object is to calculate the length of the spirals. The answer: each is equal to the length of one side of the original square. But Logo is more than turtles, and our articles will tell you what it's all about.

To get you started, Harold Abelson presents "A Beginner's Guide to Logo," Brian Harvey answers the question "Why Logo?," and E. Paul Goldenberg fills you in on the jargon with "Logo—A Cultural Glossary." Daniel Watt discusses "Logo in the Schools," and Cynthia Solomon describes "Introducing Logo to Children." R. W. Lawler explains one of the unique abilities of Logo in "Designing Computer-Based Microworlds."

Steve Ciarcia shows you how to build a graphics board for your Apple II computer using the Texas Instruments TMS9918A, and William Barden Jr. designs "A General-Purpose I/O Board for the TRS-80 Models I and III." Of course, we have Jerry Pournelle's User's Column and more.

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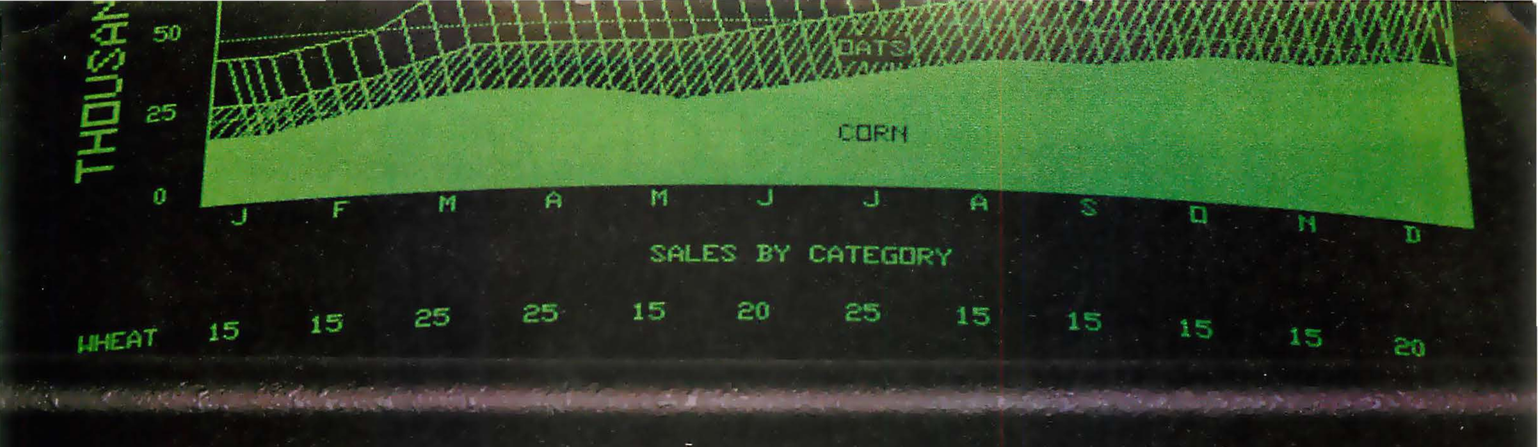
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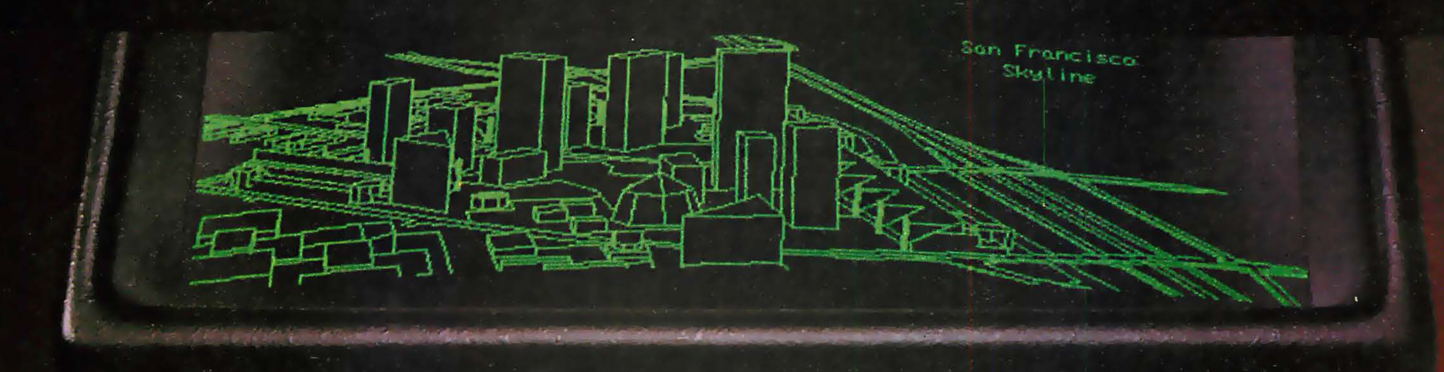
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Editorial

Keeping Our Technological Edge

by Chris Morgan, Editor in Chief

This month, as we do every August, we're devoting a portion of BYTE to a single computer language. This year's language is Logo, and we have dedicated this issue of BYTE to Seymour Papert, who developed the language.

We chose Logo this year for many reasons, but the most important is that the first computer language you learn has a lifelong effect on how you think, computerwise. Thus, the computer language we choose for use in the schools becomes vital. I believe, for reasons detailed in various articles in this issue, that Logo is a much better language to use for introducing children to computers than, say, BASIC.

Unfortunately, Dr. Papert recently left the United States, where he spent so many years advancing the state of the computer art. He now lives in France and has become the chief scientist of the newly formed World Computer Center. We wish him well, but the circumstances that led to his departure are both disturbing and encouraging. They are related to a potential crisis in American computer research and development today. Fortunately, there's still time to do something about the impending crisis. One way is through proposed legislation currently before Congress—I'll say more about that later.

I may sound alarmist in using the word "crisis" to describe the current state of affairs, especially when the mainframe and microcomputer industries are doing so well. But consider this: *three* of America's leading computer scientists have recently left the United States to be part of the World Computer Center under the leadership of Jean-Jacques Servan-Schreiber. In addition to Seymour Papert, they are Nicholas Negroponte, former Director of Computers and Communications at the Massachusetts Institute of Technology, who will become the new Director General of the Center, and Professor Raj Reddy, former director of the Robotics Institute at Carnegie-Mellon University.

The reason they left is simple. The French government had the foresight to see the need for and create a world computer center that will directly or indirectly benefit every world citizen. The United States lacked that foresight. As U.S. Rep. Albert Gore Jr. (D., Tenn.) said recently at a Washington briefing, "We have some serious thinking to do when scientists as distinguished as Nicholas Negroponte and Seymour Papert leave the United States in order to be part of the World Computer Center."

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Editorial

At that same Washington briefing Jean-Jacques Servan-Schreiber showed, in a speech by turns stimulating and troubling, just how fragile our significant technological advantage in the computer field is. For example, the Japanese have made inroads into the jet engine market. Three years ago they entered into a joint venture with the ailing British Rolls-Royce jet engine division that significantly improved the company's financial position. Again and again we hear stories of Japanese companies dominating technologies pioneered in America: liquid crystals, for example, are now made almost exclusively in Japan. The same tenacity the Japanese have shown in the automobile, camera, stereo, and ship-building fields is now being directed at the personal-computing industry, and while I am not immediately concerned about a possible Japanese "threat" for reasons I detailed in my May 1982 editorial, we must still be aware of the precariousness of our position.

The World Computer Center

The World Computer Center is a new, ambitious effort to put computer power in the hands of the people. Among the Center's proposals is a project to install a personal computer in each of 500 villages (mostly in the Third World, although some sites are in developed nations including the United States). Servan-Schreiber, the Center's director, lobbied long and hard in France to short-circuit the (as Negroponte puts it) "Byzantine" maze of French bureaucracy and create the World Computer Center in Paris that has, in one sweeping gesture,

EMPLOYMENT BY THE INFORMATION SECTOR

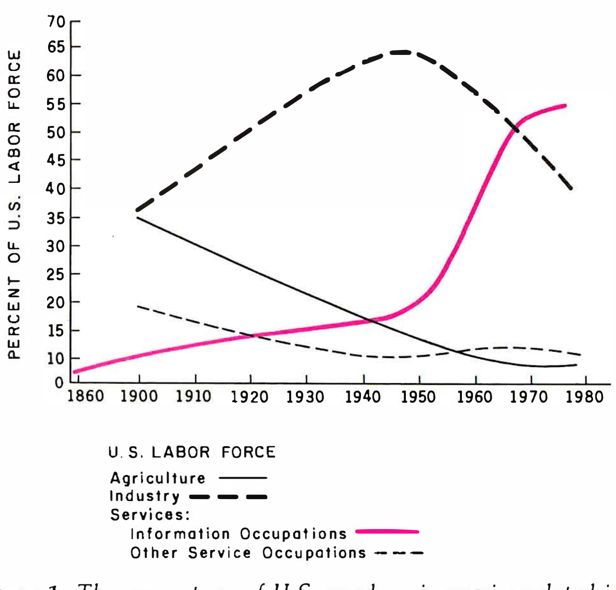


Figure 1: *The percentage of U.S. workers in service-related industries has been increasing steadily since 1860, with the most dramatic increase beginning in the 1950s. (Figures 1, 2, and 3 courtesy of Congressional Committee on House Administration.)*

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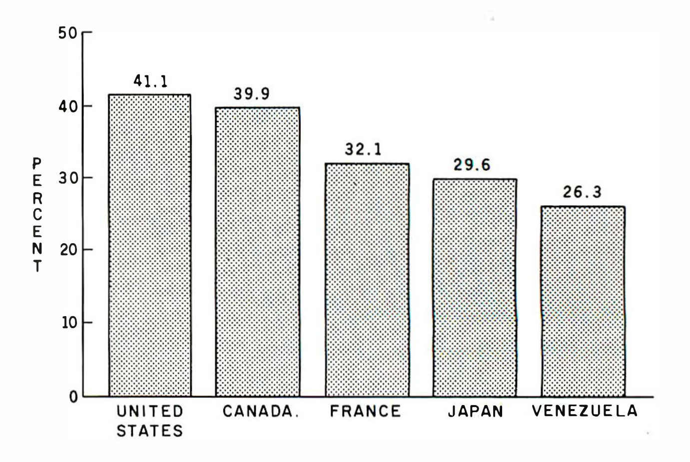


Figure 2: *With 41.4 percent of its work force engaged in information-related employment, the U.S. is the leader of the five nations represented in the graph.*

provided Negroponte with twice the resources and manpower he had at MIT, which had taken 15 years to build up to its current status.

The World Computer Center has the right idea. Take a look at figure 1. It shows the astonishing growth in the percentage of U.S. workers in service-related jobs from 1860 to 1980. Figure 2 shows the current percentages of work forces in information-related jobs by country. Surprisingly, countries like Venezuela, not normally regarded as technologically advanced, already have sizable work forces in the information field.

Servan-Schreiber takes the somewhat radical view that, in several years, human beings will no longer work the production lines. All such work, he believes, will be done by robots and machines. Therefore, he warns, people will have to learn to be processors of information. Whether or not you subscribe to this view, the trend is undeniable. Robots are attractive in many ways, not the least of which is their cost of operation. Figure 3 indicates that robots currently cost less than human workers to "employ." It's obvious to me that we must all become computer literate to survive in the future world. Yet our government is doing virtually nothing to ensure that survival.

Some Legislative Answers

One answer to the dilemma is government subsidy and encouragement of computer-literacy programs. Practically speaking, this means that personal computers must get into homes and schools. Two bills currently before Congress seek to provide financial incentives for computer manufacturers, businesses, and schools to increase their commitment to computer-literacy goals.

One of the bills, which has received a good bit of publicity, can be credited to the foresight of Steve Jobs, chairman of the board of Apple Computer Inc. The

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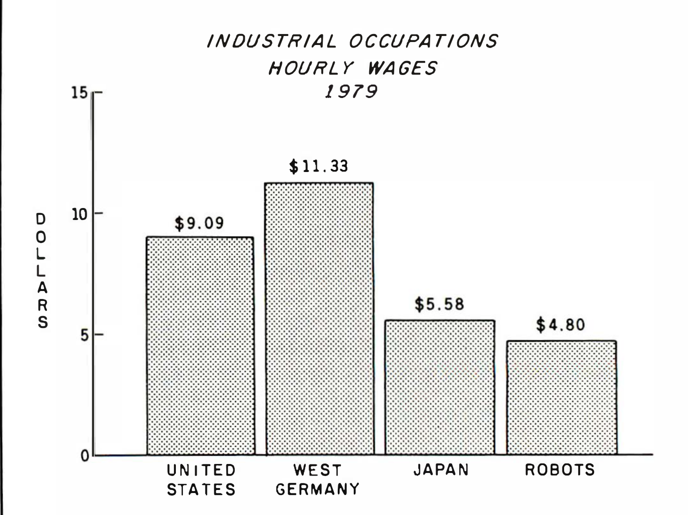


Figure 3: *This chart indicates that at $4.80 an hour robots cost less to employ than their human counterparts in the U.S., West Germany, and Japan (1979 figures).*

Technology Education Act of 1982 (HR5573 and S2281) was introduced by U.S. Rep. Pete Stark, a California Democrat. Its terms are simple: for a period of one year, computer manufacturers would be allowed to receive an increased deduction for donating computers to schools.

Built-in safeguards will assure that all manufacturers receive equal benefits. For instance, each manufacturer could give only one computer to a school. This would prevent any attempt to overpower the schools. And the computers must be state of the art. To prevent the dumping of obsolete equipment, manufacturers could not donate equipment that has been in inventory for more than two years. The manufacturer's deduction would increase from the current 50 percent of manufacturer's cost to the cost plus one half of its markup, not to exceed 75 percent of the list price. This is hardly a radical bill. Another bill currently on the books allows computer companies the same increased deduction for research equipment donated to universities. To my mind, HR5573 is a logical and much needed extension of the existing bill. I applaud Steve Jobs's willingness to push computer manufacturers into action.

The other bill, The Family Opportunity Act (HR6397), was recently introduced by U.S. Rep. Newt Gingrich, a Republican from Georgia. The Family Opportunity Act would offer a $100 per year, per family member, tax credit for up to 50 percent of the cost of a home-computer hardware or software system, with five years to write off the investment. With this bill, a family of four could buy a $4000 system and, over five years, take $2000 in tax credits.

"I want every American to have access to the same opportunities that computers provide for General Electric and AT&T," Gingrich says. "That's why working Americans should have the same kinds of tax breaks corporations get automatically."

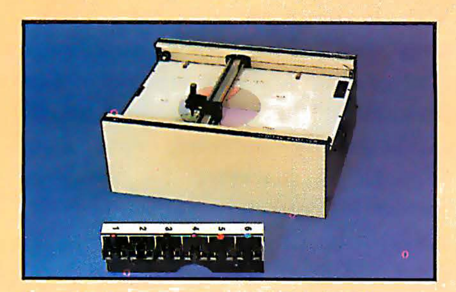
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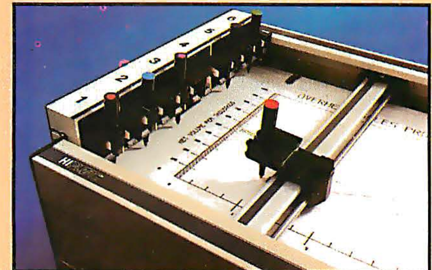
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Editorial

If you can see the value of these two bills, I urge you to write to your senator and representative. Both bills must be approved by the House Ways and Means Committee before they can be voted on. The best way to make your voice heard is to contact the chairman of that committee, Dan Rostenkowski, at the House Ways and Means Committee, 1102 Longworth House Office Building, Washington, DC 20515, (202) 225-3625. If hearings are held, they will probably be before the Select Revenue Measures Subcommittee, chaired by Pete Stark. You can contact him at his office, (202) 225-5065; direct your mail to The Honorable Pete Stark, House of Representatives, 1034 Longworth House Office Building, Washington, DC 20515. Support from both Republicans and Democrats is essential if these bills are to get attention.

I cannot stress too strongly the need to make Congress aware of the urgency attached to the goal of getting computers into the hands of every American. Only then will we be able to hold our own in tomorrow's computer society.

* * *

Software Arts' TK Solver

Software Arts Inc., in case you've forgotten, is the company that created the immensely successful Visicalc program. Now that company, headed by Visicalc co-authors Dan Bricklin and Bob Frankston, has announced the first product to be marketed by Software Arts itself (Visicalc is marketed by Visicorp, formerly Personal Software). TK Solver (see photo 1) allows you to enter a series of formulas in a natural format (for example, "distance = time × speed"); it then compiles a list of all the variables. You can then give it a set of known values and tell it to solve for the unknown ones; it either does so or tells you why it cannot.

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FUNCTION STRIP	79.00
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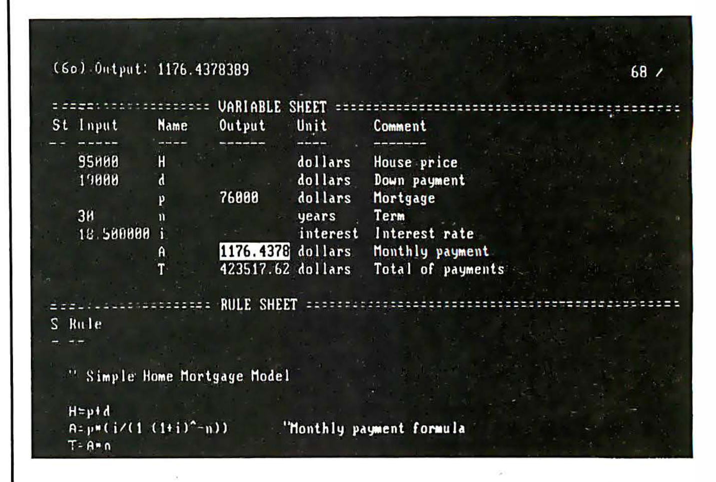


Photo 1: *The new TK Solver, from Software Arts, lets you enter a series of formulas in a natural format.*

TK Solver will initially be available for the Apple II and the IBM Personal Computer. It will be on the market later this year at the price of $299. Also available will be various application packages that will supply a predefined set of rules concerned with a given specialty; these will probably be in the $50 or $100 price range.

Sound simple? Of course, but then so does Visicalc when you describe it. The basic idea has several good things going for it. First, it is extremely well human-engineered—it has to be because its potential users are not necessarily computer-oriented. Second, it automates repetitive calculations, thus giving you answers faster and more accurately than you could do yourself. Third (and most important), it allows you to do problem solving with a body of equations *without your having to manipulate them algebraically*.

Software Arts says that TK Solver lets the professional use the microcomputer as a problem-solving tool without having to learn programming. Will this product be as big a hit as Visicalc? Only time will tell, but look for an in-depth review of TK Solver in an upcoming issue of BYTE.

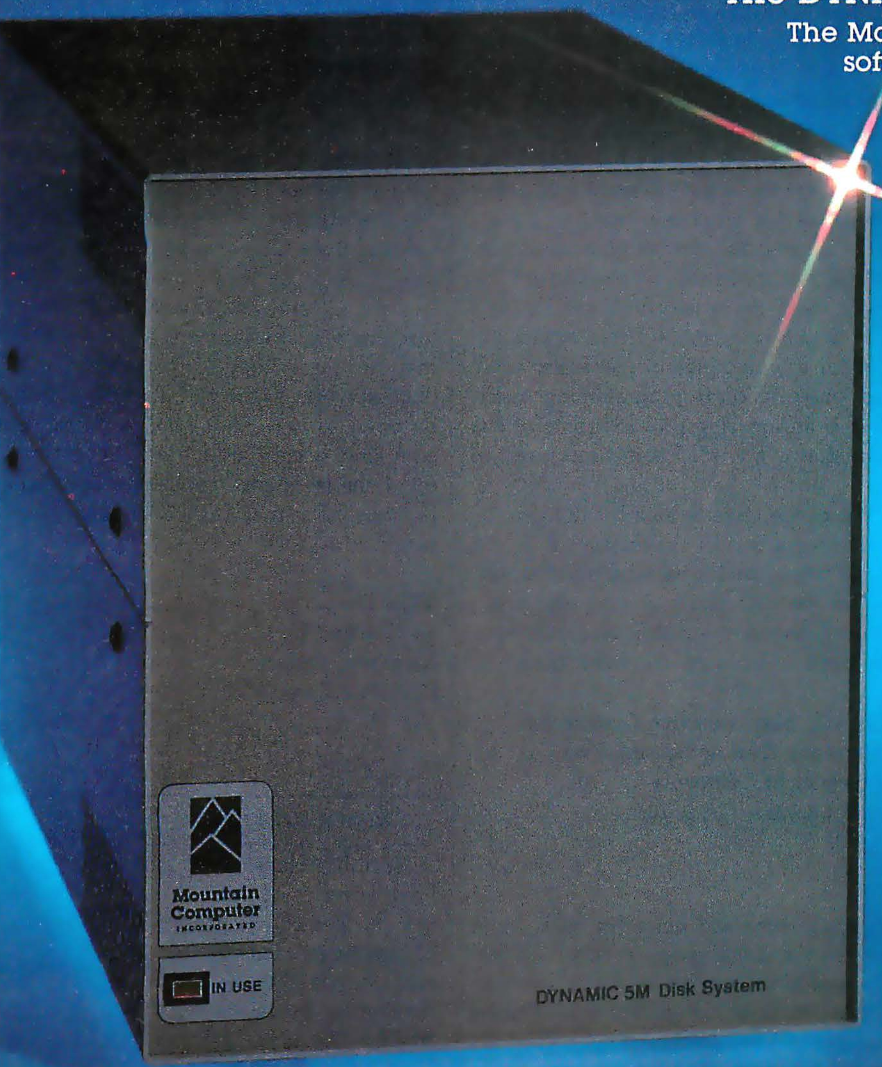
* * *

Omission

On page 70 of the May 1982 issue of BYTE we inadvertently omitted a distributor for the NEC PC-8001A. In addition to the distributor listed, NEC Home Electronics (USA) Inc., Personal Computer Division, 1401 Estes Ave., Elk Grove Village, IL 60007 (312) 228-5900 also will provide all components in the PC-8000 series. We regret the omission and hope our readers will find this new information useful. Our thanks to Thomas L. Priestly, General Manager of the Personal Computer Division, for pointing this out to us. ■

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Letters

Commodore Comments

I am writing concerning the article "A Human-Factors Case Study Based on the IBM Personal Computer" by Robert G. Cooper Jr., Paul Thain Marston, John Durrett, and Theron Stimmel (April 1982 BYTE, page 56), in which a comparison of business-oriented microcomputer keyboards was included.

The Commodore keyboard used was from a PET 2001 series microcomputer, and while we appreciate being included in the comparison, certain factors must be considered: first, the PET 2001 has not been in production for about two years; second, the PET 2001 is oriented for education, not business, and our business-oriented microcomputer, the CBM 8032, was not included in the comparison.

We realize that the article and comparison were done by nonstaff authors, but we want you to know that we would be more than happy to cooperate fully with BYTE, its in-house staff, and freelancers in order to ensure that your readers get the latest and most accurate information possible about all Commodore products.

David A. Kaminer, Director of Public Relations
Computer Systems Division
Commodore Business Machines Inc.
The Meadows
487 Devon Park Rd.
Wayne, PA 19087

Unix Feedback

I find I grow tried of the Unix-versus-CP/M argument, particularly as it is phrased by people like John Lynn Roseman (April 1982 BYTE, "Letters," page 22): "Unix is a full-featured operating system which is widely regarded as the finest ever written, while CP/M is little more than a program loader." Really? I defy anybody to take a competent secretary and make him or her a useful word-processing person on the Unix EX/VI in less time than it takes to get your work done on the CP/M Wordstar system.

And I don't like the crystal-ball predictions and dogma-before-the-fact apparent in Mr. Roseman's statement: ". . . we can be sure that the commercial software which will eventually be available under Unix will be of higher quality than that found in the CP/M market." We can?

I direct your attention to an article by Donald Norman that appeared in *Datamation* magazine all the way back in November 1981 (page 139 and following). It is titled "The Trouble with Unix," and it hits a number of nails on the head. Although I am fluent in a number of dialects of a number of languages and in a number of operating systems, I still haven't found the ultimate anything. CP/M has a number of serious limitations, but so does Unix (and so does anything else I have ever used).

Allow me to paraphrase Norman's conclusions, in which he states his three most important concepts for system design: be consistent, provide the users with a clear idea of what is going on at all times, and provide mnemonics as aids to us poor humans. I would add a final imperative: remember the users' context. In other words, decide what you want to have a given system do, and for what audience. CP/M is a tremendous environment for single users doing word processing and data acquisition; BASIC is a wonderful tool for a wide range of (generally small and one-of-a-kind) programming tasks; Unix is an amazing tool for some of the data-intensive work I sometimes need to do.

But please, give us all a break from the search for a perfect system for all people for all time. Provide me with information, tell me (as objectively as possible) about the tools that are available, and then leave me alone so I can get my work done.

Jeffrey L. Star, Research Geographer
Geography Remote Sensing Unit
University of California
Santa Barbara, CA 93106

I have some sad news for John Lynn Roseman and the recent crop of university-type Unix supporters. Unix has been running on 16-bit computers called Digital Equipment Corporation (DEC) PDP-11s for many years. There have been some other operating systems for the same machines. Guess which operating system is *not* at the top of the popularity list?

The most popular operating system on PDP-11 computers large enough to run Unix is RSTS/E. The primary language used with RSTS/E is BASIC PLUS, not the "powerful C language." While RSTS/E is used in the commercial PDP-11 environment, RSX11M is more popular on the scientific systems. When DEC introduced the VAX11 superminicomputer, it did not select Unix but rather upgraded RSX11M. I have never even seen an advertisement for a programmer with Unix or C experience.

This is not meant as a criticism of Unix or C, nor is it meant to endorse RSTS/E or RSX11M. I would be tempted to write off RSTS/E as a primitive, crude system except that it is enormously popular and its users extremely enthusiastic. The marketplace is different from the university classroom. The needs of the end user are different from those of the system software developer.

CP/M is a rinky-dink kind of operating system. It does, however, do most of what most microcomputer users want, with a minimum of fuss. I have used various operating systems on IBM, DEC, and Control Data Corporation machines, and I don't feel neglected or abused by CP/M.

Unix, C, and Pascal may be excellent teaching and development tools, but they may not be so good for commercial production work. While we "old-timers" must be open to new ideas, the new crop of computer science graduates must keep in mind the difference between theory and practice. (By the way, what ever happened to ALGOL?)

Mike Draper
18 Cowdy St.
Kingston, Ontario
K7K 3V7 Canada

More on Human Factors

Hurrah! Hallelujah! Human factors have arrived. While BYTE has occasionally published comments on the importance of making computer systems easy to use, I was overjoyed to see human factors engineering as the theme for the April 1982 BYTE. The article "Designing the Star User Interface" by Dr. David Canfield Smith, Charles Irby, Ralph Kimball, Bill Verplank, and Eric Hanslem (page 242) was particularly outstanding in showing how human factors can be incorporated into the design process.

However, several points about human

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factors and computer system design that do not emerge from the April issue of BYTE as a whole need to be emphasized.

First, human factors need to be considered very early in design, well before the first line of code is written or the first circuit developed. Specifically, to ensure that a product will be human engineered, design from the outside in. First construct the user interface and write the user's manual. Everything else should follow. All too often the situation presented to human factors experts is: "We have built this system and are delivering it tomorrow. Isn't it wonderful? Please bless it."

Second, test, test, test. Throughout the life of a system observe user performance. Begin with simulations during the conceptual phase and conduct further tests in succeeding phases—on the documentation, on the first prototype, on the first production system, and on systems that have seen considerable operation. The focus should be on what the user does and how the system responds. While the opinions of human factors experts and user surveys provide clues about improvements, *it is essential to collect time and error measures of user-computer interaction*. A modicum of concrete data outweighs many opinions. Also keep in mind that computer scientists and engineers are poor critics of the friendliness of the systems they build and are not the best test subjects. They know far more about the internals of computer systems and differ in many other significant ways from ordinary users.

Third, human factors work, while sometimes costly, is money well spent. Project managers are often reluctant to spend funds for human engineering when there are more conventional projects to support (for example, developing file managers that require less memory or power supplies that run more coolly). Human factors considerations are an integral part of design and should be assigned a commensurate priority and funding. Managers need to appreciate that users don't care why a system doesn't work. To users, incomprehensible commands, and error messages, inscrutable manuals, computational errors, and blown fuses are all equally bad.

Finally, one does not become a human factors expert by being annointed by one's supervisor, living with a system, or just being human. Human factors expertise is obtained primarily through experience and special training in such areas as statistics and experimental design, sensation, perception, cognition, time and motion study, safety engineering, occupational health, biomechanics, work physiology, and anthropometry. In addition, one should complete several courses specifically dealing with human factors engineering.

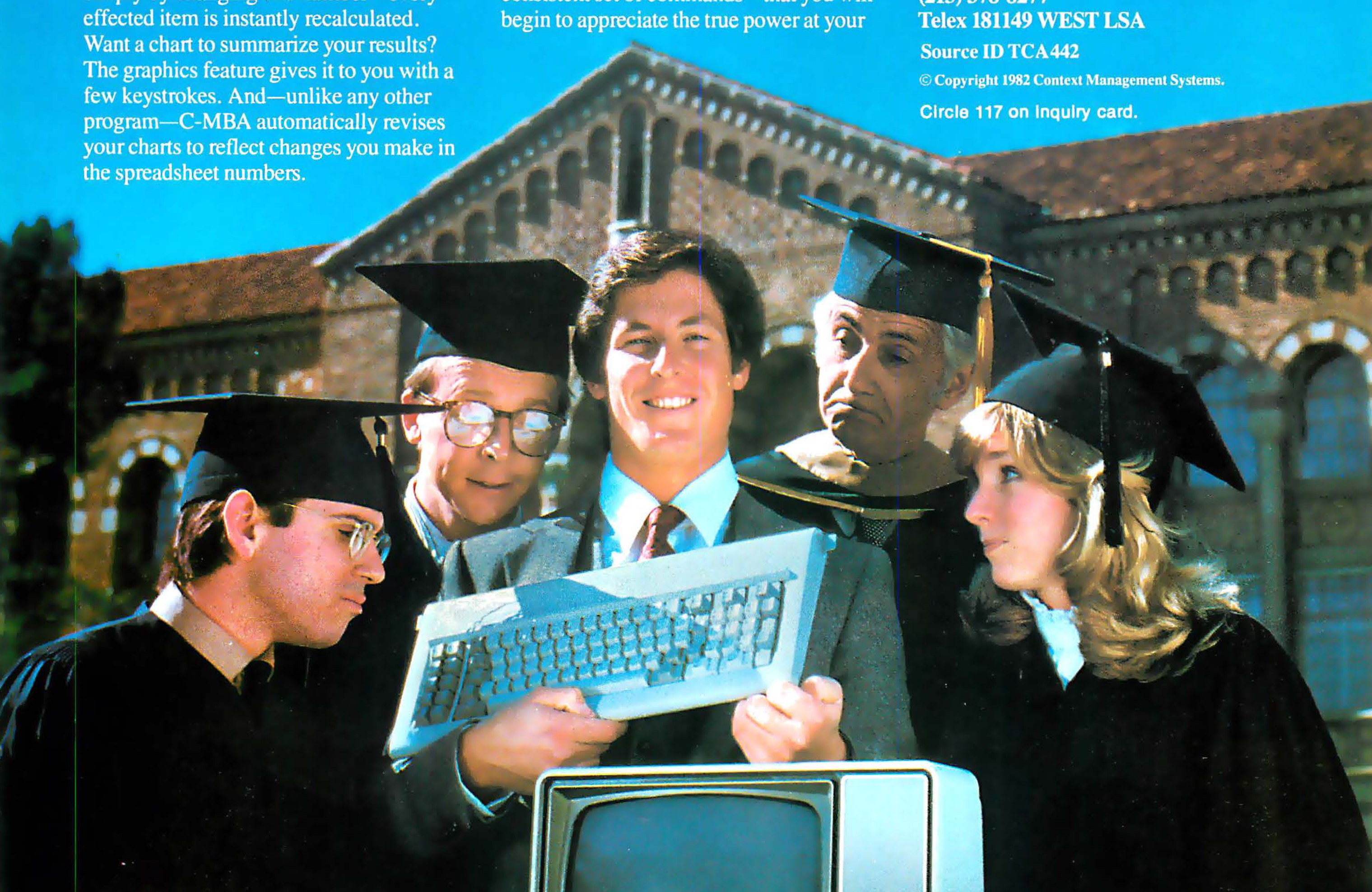
Paul Green, PhD
HSRI—Human Factors
University of Michigan
Ann Arbor, MI 48104

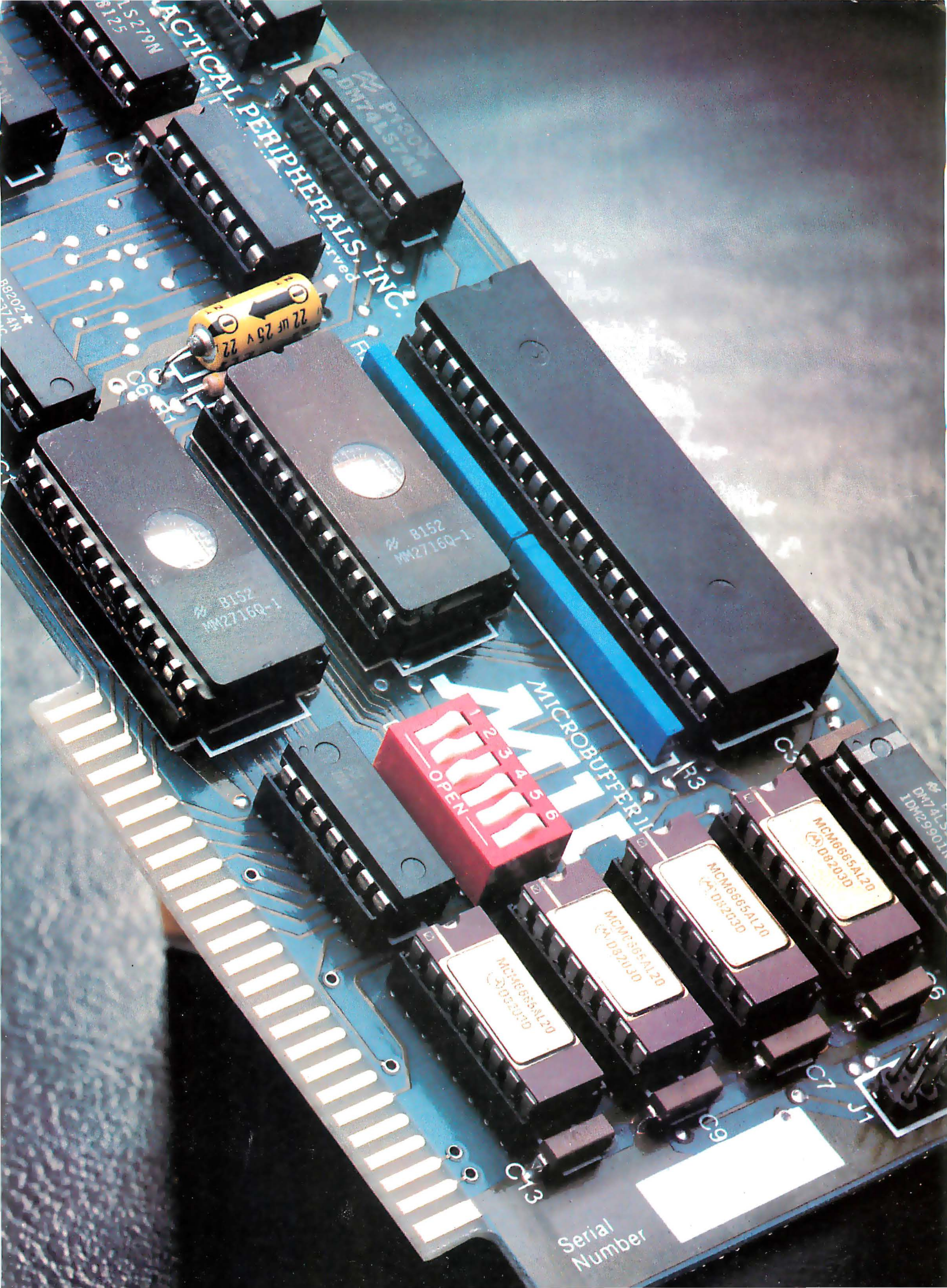
I have just finished reading the April 1982 BYTE, the issue devoted to human factors engineering. While some topics were discussed adequately, I feel the issue lacked a general discussion of the human-machine interface. It is the user interface that is the most important issue in determining how user-friendly a system is to be. Only after this subject is carefully treated can the aspects of program design be discussed. In this respect, the article "Designing the Star User Interface" presents an example of one way to implement the man-machine interface.

Currently, the most reliable low-cost man-machine interface is the touch screen. Touch screens allow the simplest possible user interface. Users visually see what item they're interested in, then reach out and touch it. The computer system then responds. Since it relies solely on the users' visual and tactile senses, no prior training is required.

Our experience in the creation of touch-sensitive database systems in library catalog, hospital, merchandising, publishing, and other public-use applications suggests that this technology will rapidly become dominant in environments where training of the user is not feasible or practical.

From a human factors point of view, we have learned that there are also additional considerations that improve the prospects for the success of a system in use. First of all, we have found that a combination of visual and aural responses supporting the physical sensation of touch creates a strong feeling of comfort. Using inverse video or highlighting the touched region and ringing the audible bell have proved to be helpful features. Also, if the user touches a region of the screen not relating to a valid choice, the response should be similar to that for a valid touch, but the region of the screen touched should restore to normal video almost immediately. This action tells users that the




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equipment is working and thus they have simply touched an invalid region for this particular point in their use of the system.

The design of data formats for successful touch-based systems should follow guidelines similar to those which have evolved for the design of keyboard-oriented systems; i.e., the processes should mirror and reflect the functions to be performed. One additional consideration is that menu items should be separated from each other to accommodate the accuracy of the human finger. Typically, touchable menu entries should be displayed either double the normal text size or on every other line. This spacing allows almost any user to touch the desired selection on the first try. Software products which convert the menus of already existing programs to convenient touch-screen formats are commercially available and inexpensive.

Your readers should feel free to contact us if they desire additional information about the touch-sensitive technology.

Jonathan J. Bloom, Marketing Manager
Interaction Systems Inc.
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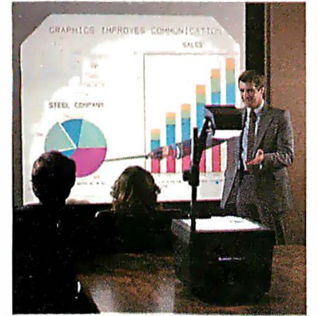
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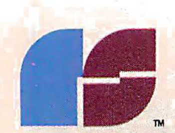
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software, therefore, depends not only on the local microcomputer but also on modems, telephone lines, and a remote IBM processor running mainframe communications software. The possibilities for undetected protocol errors are enormous because all of these components normally function correctly and boundary conditions are not usually encountered in normal operation.

How, then, can we offer a warranty? By testing, testing, and testing! We have developed both hardware and software test vehicles that allow us to simulate all components of the communications path that are external to the microcomputer, including the local microcomputer operator and the remote IBM processor. Using these test harnesses we can perform functional tests that ensure that each function of the software performs as advertised and stress tests that test boundary conditions, host-generated protocol errors, and performance under high load. Any errors that slip through the test suites and are reported by customers are then incorporated into the test suites to ensure that any problem reported is never again present in a release. The software becomes more and more stable as a function of time.

From a user's viewpoint, a software warranty means that you can count on (1) getting the level of customer support needed to make the software run in your environment, (2) the software's being very stable once it is running, and (3) receiving patches and updates that correct problems found by other users.

This implies, from the vendor's viewpoint, that (1) the software must be easy to set up and run (or the vendor must have a huge customer service staff) and (2) the vendor must be prepared to expend a lot of time and money in sending out updates if the software is not stable.

We believe that the time and money spent testing, supporting our customers, and sending out updates (yes, we still find occasional bugs) is well worth it. We couldn't live with ourselves if we sent out junk that had little chance of running. Our customers deserve the best we can provide—after all, they're paying our salaries!

John A. Parsons, CDP
President
Micro-Integration Inc.
63 Maple St.
POB 335
Friendsville, MD 21531

Misrepresenting the Videotex Standard

I read with interest Chris Morgan's editorial, "Of IBM, Operating Systems, and Rosetta Stones," in the January 1982 BYTE. Of particular interest was the mention of Microsoft's device driver for the AT&T proposed videotex graphics standard. For your Canadian readers you might point out that the AT&T system is based on the Telidon coding system developed by the Federal Department of Communications in Ottawa. Mr. Morgan is in error, however, in the implication that this is a low-resolution standard. It is, on the contrary, an extremely high resolution standard, allowing up to an incredible 24 bits of data to specify each x and each y coordinate. This, admittedly, exceeds the capability of any current hardware including the printing press.

The key and the beauty of the system, however, is in the concept of the unit screen, which treats these data bits as decimal values between 0 and 1, thus achieving hardware independence and upward compatibility.

If you probe the standard further, you will see similar capability and expandability in all aspects of the code, including color, character fonts, text sizes, and the like. It is anything but a minimal standard.

It may be of interest that a Unix-based system has been written to meet the earlier Telidon standard (of which the AT&T system is essentially a superset).

Robert A. Abell, President
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Edmonton, Alberta
Canada

We thank Mr. Abell for setting us straight about the videotex graphics standard. We are currently working on an issue, to be published in early 1983, that will be devoted in large part to the subject of standards in the microcomputer industry. . . . C. M.

The Last Laugh

I was much amused by your facetious entry in the What's New? section of the April 1982 BYTE (page 424) concerning the hard disk for the ZX81. I'm afraid the joke is on you, however, and I quote from a recent press release ("Micro Forecast," Vol. 3, No. 5):

After the first £100 computer—the ZX80—two years ago, Sinclair are looking to become the first company to market a £100 disk drive.

The project to produce a low-cost mass memory storage on hard disk for personal computing will be led by Rodime, the Glenrothes-based, all-British disk drive company, if agreement can be reached between the two companies.

The new disk drive will use 3½-inch rather than 5¼-inch hard disks and both Sinclair and Rodime hope that users of the ZX81 will take up the disk-drive facility when it becomes available, creating a new £250 million market for the disks. At the same time it will give the ZX81 and future Sinclair computers an enormous boost as the battle for a share of the microcomputer markets heats up.

Rodime, who will develop the disks, say there are no serious technical problems preventing them from going ahead with a 3½-inch disk and claim that with or without Sinclair they will be marketing one by 1983.

The problem of bringing the cost down, however, could confound Rodime and it would need Sinclair's mass market as well as their gift for making a success of low-cost computing before they could seriously contemplate a £100 price tag.

Sinclair meanwhile are not expected to be involved in selling the disk drives for some time yet. The first proposal came from Rodime, and Sinclair will need to overcome technical problems and plan production—possibly from the Timex plant where the ZX81 is built.

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What's the Story, Jerry?

I have enjoyed BYTE's "User's Column" by Jerry Pournelle for some time now. He has presented products through the eyes of an actual user, rather than an impartial reviewer, with some amusing results (it took me three days to stop laughing at his "review" of Microproof [April 1982 BYTE, page 212]). This "actual user" view brings things down to earth.

However, I'm starting to doubt that Mr. Pournelle and I are on the same planet. He gets phone calls from Arthur C. Clarke ("Long-distance from Sri Lanka, Mr. Pournelle. . . ."), and when he has some questions about Godbout products, he calls Bill Godbout himself. To make myself feel better, I tried looking up Joe Northstar in the Osceola County phone book (I had a few questions myself), but to no avail.

I'm also getting the teensy-weensiest bit tired of Mr. Pournelle's telling us losers about "*the* way to go" for his money. It would be my way to go too, if it were still *his* money. He proceeds to describe a system (oh, what a system) that I've dreamed about having (with a few minor additions) for years.

And now he sells his own software: "I've always liked it [his program], and I'm happy to share it." For a price, no? Why not share it in the pages of BYTE? Alas, the rich get richer. . . .

The most comforting thing I've read in "User's Column" is that Mr. Pournelle owns a TRS-80 Model I—a souped-up TRS-80, but that which we call a TRS-80, by any other name, would still run at less than 4 MHz.

I do hope all I've written so far just points out how envious I actually am of Mr. Pournelle, or at least of his hardware and software. But if he wants to publish Arthur Clarke's or Bill Godbout's home phone numbers, that's fine with me.

One more thing: besides the fact that everyone except myself has infinitely better computer stuff, do all computer owners except myself have names for their computers? Mr. Pournelle insists on calling one of his computers "Ezekial," or "Zeke," instead of the more obvious "Z-2," and I have a friend who calls his dad's TI bubble-memory terminal "Benny." I myself admit to calling the two lamps in my bedroom "Scott" and "Zelda," but I call my OSI C1P "my OSI C1P," or "the damned computer" for short. Maybe having names for one's

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hardware is a function of the cost of it; perhaps Mr. Pournelle could speculate on this in the next "User's Column."

All in all, the "User's Columns" are the best reading I've had since *The Mote in God's Eye* by Larry Niven and Jerry Pournelle (Simon and Schuster, 1974), and to me they are not in different classes. (I'm as likely to be capable of purchasing Qume double-sided double-density drives as I would be capable of purchasing an Alderson Drive.)

Karim Alim
2414 Sable Drive
Kissimmee, FL 32741

Jerry Pournelle replies:

I'm glad Mr. Alim (usually) likes my columns. As to my friendships with Bill Godbout and Arthur Clarke, what am I to do? I can't believe Mr. Alim really believes that those unable to talk with everyone should speak to no one.

Regarding "dream" systems: the last time I looked, Priority One was selling the VISTA box with two Qume DT-8 drives for $1600. This isn't cheap, but I noted yesterday that my local membership discount department store sells 5¼-inch drives for Atari 800s at about $475, and I expect $500 is closer to what you'd pay at a regular store. I'd rather pay the extra $600, which is indeed what I did; I do, after all, trust my livelihood to my machines.

I make no secret that I believe the best way to go is to get a good S-100 bus with the best disks you can buy: later on you can replace the boards in your computer. Iron's expensive, but silicon's getting cheaper all the time.

Regarding my letting Barry Workman sell my programs: I worry about that, but I've neither the time nor the ability to be a publisher, and Barry neither can nor will do it for free. It seemed to me that making the programs available is worthwhile and does no harm.

I've asked Zeke about computer names, and he tells me that his electronic friends enjoy having human apellations; it makes their humans think they are somehow the equals of computers.

I'm glad that Mr. Alim likes my other works.

Looking for Adventure

Help! Is there really no adventure game other than the original adventure for CP/M systems? Nothing like the Temple of Apshai or Invasion Orion and all the others? Is there no one out there who has a heart for all the owners of nice CP/M systems who want to play and cannot afford to buy an Apple for this reason alone? I went through all BYTE issues for that matter, and whenever I find the new BYTE in my postbox I go through it, but no, everything is for TRS-80 or Apple. Every mornin' finds me moanin'.

Hans Strasburger
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Advice for Apple

I'm a relatively new reader of your excellent publication, but a letter from

Dennis Pratt in the March 1982 BYTE (see "Apple's Decision Questioned," page 14) concerning Apple Computer Inc.'s decision to restrict mail-order and telephone sales struck a responsive chord. Having followed the development and success of the personal and small-business computer market, I'm simply amazed that Apple is attempting to justify its actions with the excuse that customers can be served properly only through the retail outlet. Because all versions of the Apple were available through the mail up until the end of last year, I suppose the company is implying that its customers are now much less intelligent than they once were. If you believe that Apple's motives are anything other than pure economics, then you probably also believe that the intense competition for the personal computer market is simply a passing fad.

If I were in the Apple boardroom, however, I would worry. As I sit here typing on my non-Apple system and consider the number of personal computers that are now on the market, many available through multiple sales outlets (i.e., retail, mail, etc.), I can only suggest that the people at Apple rethink their policy. Don't they realize that Apple is not the only game in town anymore?

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Stick to Computers

In addition to learning from the wealth of information contained in the various articles in each issue of BYTE, I find that I also learn a substantial amount by reading the advertisements of the latest products. I am delighted that your magazine has such a diversity of computer products presented in each issue.

This brings me to a problem, however: I really don't care to see advertisements for the Heirloom Library, Ford Motor Company, or whoever else is willing to pay for a page of BYTE.

Please, stick to computers and directly related products and services!

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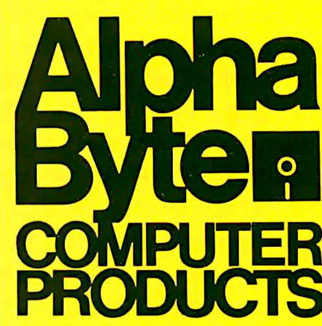
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Program Generators

They're not as easy to use as some advertising copy suggests.

George Stewart
Technical Editor

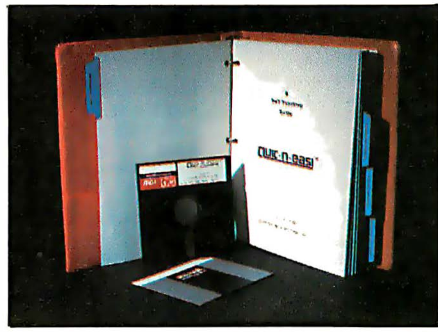
Would you like to be able to tell your computer what you want it to do without ever having to learn a programming language? Well, you can. You simply tell your computer what you want in layman's terms, and it figures out how to accomplish your wish and creates a program to do it.

The software tools that perform this feat are called program generators or application generators. (Technically, a program generator creates a *stand-alone* program that you can list, store, copy, and use. An application generator, on the other hand, generates a software package that is dependent on the application generator: to run your generated program, you use a *run-time* portion of the application generator. In this article, I'll use the term *program generator* to include both kinds.)

The first program generators were written for mainframe computers back in the late 1960s. Their purpose was to increase the productivity of data-processing departments. Now several have been announced for microcomputers and, for the first time, are being aimed at nonprogrammers as well as professional programmers.

Photos by Katherine Coker





The most heavily and boldly advertised package is The Last One, $600 from D. J. 'AI' Systems Ltd. One typical ad starts out with the headline "Your prayers have been answered." Understandably, the promotion has produced considerable skepticism and controversy in the computer community. Another product introduced with less fanfare is Quic-N-Easi, $395 from Standard Microsystems Inc. I'll use these two products as examples in this background report on program generators. (For more specifics on each product, see the text boxes.)

How Program Generators Work

Program generators are *problem-oriented* rather than *procedure-oriented*. In other words, because the program generators possess information about common programming problems like keyboard entry, file input/output, and data sorting, they let you concentrate on the problem you're trying to solve rather than on the special computer procedures required to solve it.

Let's say you want a program that creates a mailing-list file on a floppy disk. First, of course, you must decide exactly how you want information stored in that list—even a manual, paper-based system requires that much. Do you want to store the names in alphabetical order or by member ID? Last name first or vice versa? What's the longest name and how many lines are in the address?

You must also specify the exact steps for inputting and storing names. You would have to do much the same thing if you were explaining your wishes to another person instead of to a computer. Table 1 summarizes the

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At a Glance

Name
The Last One

Type
Program generator

Manufacturer
D. J. 'AI' Systems Ltd.
Two Century Plaza, Suite 480
2049 Century Park East
Los Angeles, CA 90067
(213) 203-0851

Price
$600

Format
8-inch or 5¼-inch floppy disks

Language
BASIC

Computer
CP/M systems, Radio Shack TRS-80 Model II, Apple II, Commodore PET

Documentation
Tutorial manual plus machine notes for specific computers

Audience
Nonprogrammers who want custom software

At a Glance

Name
Quic-N-Easi

Type
Program generator

Manufacturer
Standard Microsystems
136 Granite Hill Court
Langhorne, PA 19047
(215) 968-0689

Price
$395

Format
8-inch or 5¼-inch floppy disk

Language
Machine code

Computer
CP/M systems, Radio Shack TRS-80 Model III

Documentation
Three-ring binder containing tutorial, quick-reference card, and programmer's reference

Audience
Nonprogrammers who want custom software and programmers seeking to speed programming efforts

steps you might take in planning your mailing list.

Now how do you communicate all this information to a program generator? If the program generator is to be useful for nonprogrammers, most of your work should already have been done (in the planning phase just described). You'll probably communicate with the program generator in three phases: data description, screen design, and program procedure.

Data description tells the computer how many pieces of information (fields) exist in each logical file entry (record) and what kind of data goes into each. *Screen design* is the arrangement of headings and prompting messages that the operator will see on the screen. *Program procedure* tells the computer what to do with the data that is typed in. Data description and screen design are relatively straightforward, but the program design phase is where the program generator really shows its stuff (or lack of it).

After you've completed the program specification, the generator will take care of the programming details, asking you for additional information whenever necessary. Figures 1 through 4 and listings 1 and 2 show uses of The Last One and Quic-N-Easi to specify the mailing-list application.

Using an ordinary programming language, your task is far more involved. The data description, screen design, and program procedure all must be coded in computer-language statements covering a multitude of details: how to create and initialize a disk file, input each data item from the keyboard, write each completed record to disk, etc. Including steps to handle errors (keyboard mistakes or disk problems) is an especially intricate and burdensome task. Instead of focusing on your problem in layman's terms, you must convert it into technical terms.

Evaluating Program Generators

In your evaluation, you should look for capabilities in six general areas: data entry, program logic spec-

ification, file storage, report generation, calculations, and editing convenience.

Data entry: Getting information into the computer, as illustrated in the mailing-list application previously described, is the bread and butter of program generators. It's the simplest part of most programs and yet often the most tedious to program. A good program generator should allow easy creation of display forms, the screen layouts that prompt the operator for data. Photo 1 shows a typical display form. Ideally, you should be able to construct the display form on the screen, not on paper, and modify the screen-input form without modifying the entire application program. Checks for invalid entries should be provided automatically by the program generator.

Program logic specification: How hard is it to tell the computer what you want? That depends on how much knowledge is embedded in the program generator. To take a few minor examples, does the program generator know what alphanumeric data looks like (A–Z, a–z, 0–9, ., +, −), or do you have to make up a procedure to check the validity of each entry?

As a general rule, if an operation is generically repetitive (such as searching through a table for a specific entry), you shouldn't have to take great pains specifying the procedure to accomplish it. If you do, then you, not the program generator, are doing most of the programming work.

File storage: This is an important characteristic of program generators, and it may take some careful study. Does the program generator allow both major types of file storage—sequential and random access? Sequential access allows you to read information in the same order in which

Description of each member record:
Last name (15 letters)
First name (10 letters)
Member ID (5 digits)
Date of last contact (8 characters as mm/dd/yy)
Street (25 characters)
City (20 letters)
State (2 letters)
Zip (5 digits)

General description of program operation:
1. Ask operator to type in a record (e.g., information for one member).
2. Check all entries for validity.
3. Write the information to the disk file.
4. Ask operator if there are member records to be entered; if there are, then repeat step 1.
5. If not, end the program.

Table 1: *Details of mailing list to be worked out before using the program generator. Numbers in parentheses are maximums for each item.*

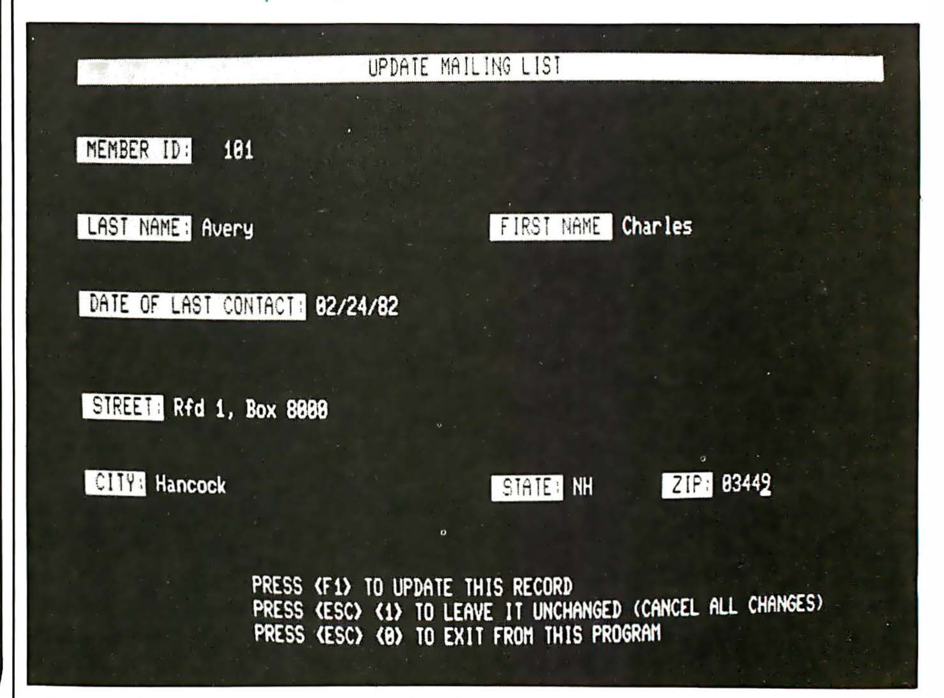


Photo 1: *A data-entry screen created with Quic-N-Easi.*

Field	Field Label	A/N/D	Field Size
1	LAST NAME	Alpha	15
2	FIRST NAME	Alpha	10
3	MEMBER ID	Numeric (0)	6
4	DATE OF LAST CONTACT	Date	8
5	STREET	Alpha	25
6	CITY	Alpha	20
7	STATE	Alpha	2
8	ZIP	Numeric (0)	6

Figure 1: *The data description for the mailing-list program using The Last One.*

```
1       .. Open MEMLIST file
2       .. Set pointer to the end of MEMLIST file
3       .. Keyboard input using labels from MEMLIST
4       .. Write data to MEMLIST file
5       .. Ask user < ANY MORE RECORDS TO ENTER >. If yes branch to 3
6       .. Terminate program
```

Figure 2: *The procedure description for the mailing-list program in the form of a general flowchart using The Last One.*

Listing 1: *A small part of the BASIC mailing-list program generated by The Last One. The total dialogue required to specify the program is not shown. The application specified here is for entering new records only; another program would be needed to update existing records.*

```
8  CLEAR 5000:DEFDBL N:DEFINT R:ONERRORGOTO60000
9 DIM AA$(8)
10 CLOSE:OPEN"D",1,"MEMLIST:1",92
11 FIELD 1,15 AS AA$(1),10 AS AA$(2),6 AS AA$(3),8 AS AA$(4),25 AS AA$(5),20 AS
AA$(6),2 AS AA$(7),6 AS AA$(8)
12 RC(1)=LOF(1)+1
13 CLS:X8=0:X9=0
14 PRINT@(1,26),"MAILING LIST CREATION PROGRAM"
15 PRINT@(6,1),"LAST NAME":PRINT@(6,12),STRING$(15,46):PRINT@(6,12),;:LINEINPUTS
$:IFLEN(S$)<=15THEN17
16 PRINT@(6,12),SPC(LEN(S$)):GOTO15
17 LSET AA$(1)=S$
18 PRINT@(6,40),"FIRST NAME":PRINT@(6,53),"..........":PRINT@(6,53),;:LINEINPUTS
$:IFLEN(S$)<=10THEN20
19 PRINT@(6,53),SPC(LEN(S$)):GOTO18
20 LSET AA$(2)=S$
```

it was written. Random access allows reading, writing, or updating information in any order. For applications that require frequent updates of information scattered throughout a file, random access is almost a necessity. Some program generators offer a third kind of file access called indexed sequential. In effect, your data is sorted automatically as it is entered. Instead of referring to data in terms of arbitrary record numbers, you can refer to it in terms of filing keys. The same thing can be accomplished through random-access files, but *you* have to provide the indexing.

Another important feature is interactivity. Do all data files have to be explicitly named during program generation, or can the end user specify files at run time? For example, suppose you have generated a sorting program. Can the operator enter the name of the file to be sorted, or does the generated program have to know about it in advance? The answer to these questions will tell you much about the flexibility of a program generator.

Equally important, what *file structures* are available? Can information be defined in a hierarchy? In a mailing list, can a list of family members be grouped under "member name" or a list of previous addresses be grouped under "address"? You can write powerful applications programs more simply if the program generator has built-in facilities for such *hierarchical data.*

Report specification: When it comes to outputting results, is it easy to explain your desired report format to the program generator? You should not have to go to great lengths to have headings and subheadings inserted at the appropriate positions. If many columns are to be printed, you

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shouldn't have to worry about squeezing them all in. The program generator should take care of that by breaking the column headings into two or more lines, etc.

Calculations: Most applications will require some calculations on the data: comparisons between names, arithmetic operations, etc. Obviously, you will need to understand the required operations fully before you can explain them to the program generator. However, you should be able to enter the necessary operations and formulas without resorting to computerese. For example, if you want to update an account balance, you should be able to accomplish this in a straightforward manner such as:

NEW BALANCE = OLD BALANCE − PAYMENT RECEIVED

You should *not* have to resort to formulas like this:

V1 = V2 − V3

Editing convenience: This may be the most important aspect of a program generator, since 60 to 80 percent of programming time is usually devoted to maintenance (modification) of existing programs. Obviously,

```
MEMBER ID: #####

LAST NAME: ###############                    FIRST NAME: ##########

DATE OF LAST CONTACT: ##/##/##

STREET: #########################

CITY: ####################                    STATE: ##          ZIP: #####

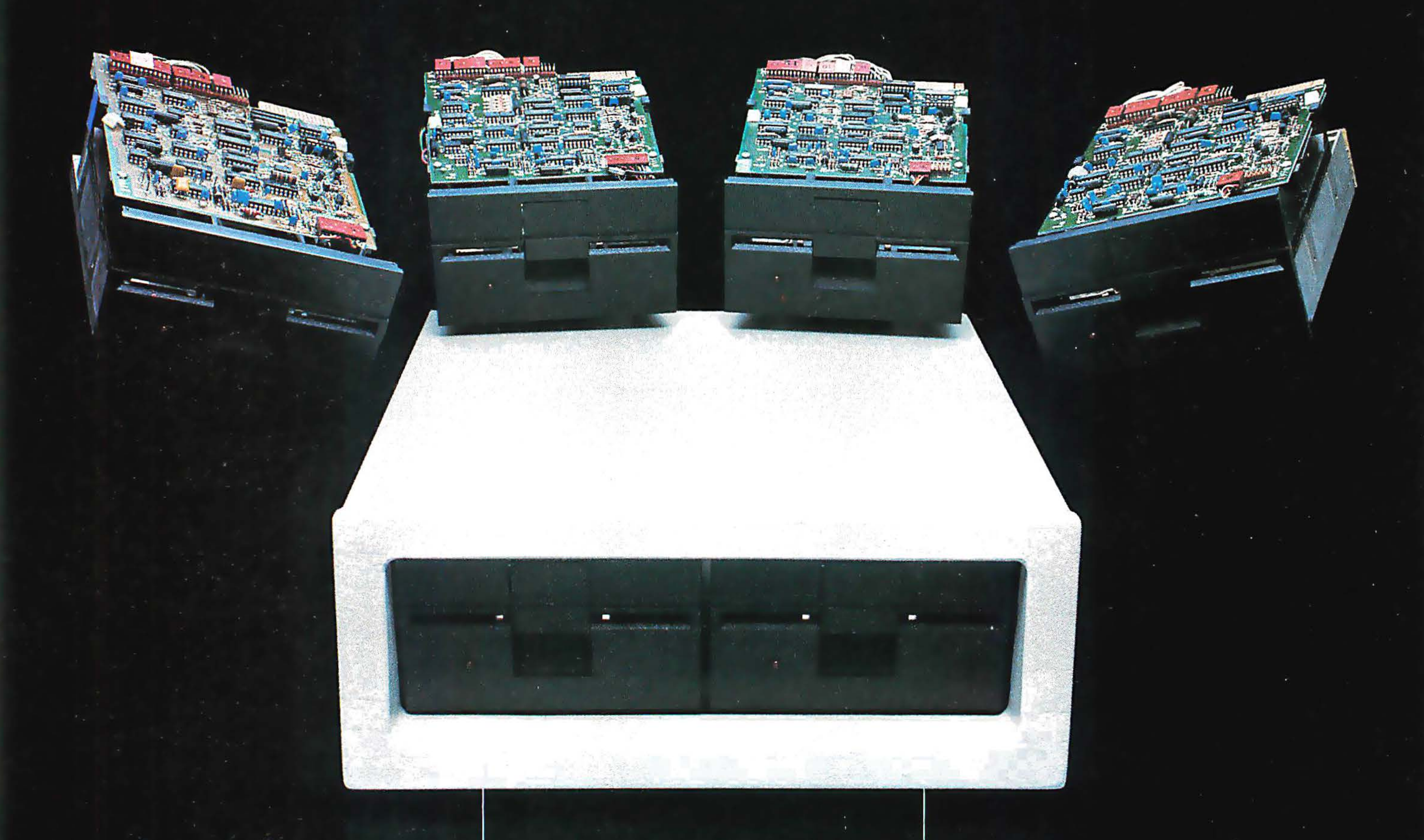
                PRESS <F1> TO UPDATE THIS RECORD
                PRESS <ESC> <1> TO LEAVE IT UNCHANGED (CANCEL ALL CHANGES)
                PRESS <ESC> <0> TO EXIT FROM THIS PROGRAM
```

Figure 3: *The screen layout for the mailing-list program using Quic-N-Easi. The "#" signs show the size and position of keyboard input fields.*

OFFSET	FIELD	LEN	R	C	DESC	JUST	FILL	MY-EN	MU-EN	MU-FL	MU-TB	PROC
0	ID	5	3	12	D	R		Y	Y	N	N	GETRECORD
1	LASTNAME	15	6	12	x	L		Y	N	N	Y	
2	FIRSTNAME	10	6	53	x	L		Y	N	N	Y	
3	MONTH	2	9	23	D	R		Y	N	Y	Y	
4	DAY	2	9	26	D	R		Y	N	Y	Y	
5	YEAR	2	9	29	D	L		Y	N	Y	Y	CHECKDATE
6	STREET	25	13	9	x	L		Y	N	N	Y	
7	CITY	20	16	7	x	L		Y	N	N	Y	
8	STATE	2	16	48	A	L		Y	N	Y	Y	
9	ZIP	5	16	63	D	L		Y	N	Y	Y	

Figure 4: *The data descriptions given to Quic-N-Easi. Column abbreviations used are LEN=field length, R=display row, C=display column, DESC=data description, JUST=justification (left or right), FILL=character, MY−EN=may enter, MU−EN=must enter, MU−FL=must fill, MU−TB=must tab, and PROC=procedure associated with this field. As soon as the operator types in a member ID number, the GETRECORD procedure gets the member record, if it has been written. The CHECKDATE procedure ensures that the operator enters a valid date as mm/dd/yy.*

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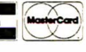
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Listing 2: *The procedures you must specify using the Quic-N-Easi language for the mailing-list application. In effect, you write this "program"; however, it is much shorter and simpler than an equivalent program written in an ordinary programming language. This application uses indexed sequential files and allows you to update existing records.*

```
 10:  * FUNCTION KEY PROCEDURE
 10:             PROC KEY0
 10:             CLOSE 1
 10:             SYSTEM
 10:             END
 10:             PROC KEY1
 10:             UNLOCK ID
 10:             HOMECLEAR
 10:             END

100:             PROC GETRECORD
100:             IF ID GE 1 AND ID LE 200 THEN GOTO 10010
100:             ERROR "MEMBER ID NUMBER IS OUT OF RANGE: [1 - 200]"
100:             CLEAR ID
100:             RESUME
100:             END
100:  10010      POSN 1 TO ID
100:             READ 1: 10020
100:             GET * FROM 1
100:             LOCK ID
100:             END
100:  10020      UNLOCK ID
100:             END

200:             PROC LOAD
200:             OPEN "MEMLIST",3,97,1: 20010
200:             END
200:  20010      MAKE "MEMLIST",3,97,10,5,1: 20020
200:             END
200:  20020      ERROR "CAN'T CREATE FILE"
200:             SYSTEM
200:             END

300:             PROC ENTER
300:             UNLOCK ID
300:             RESTART 1
300:             PUT * TO 1
300:             WRITE 1: 30010
300:             SECURE 1: 30020
300:             END
300:  30010      ERROR "ERROR IN WRITING RECORD"
300:             CLOSE 1
300:             SYSTEM
300:             END
300:  30020      ERROR "ERROR IN SECURING FILE"
300:             CLOSE 1
300:             SYSTEM
300:             END

400:             PROC CHECKDATE
400:             IF MONTH LT 1 OR MONTH GT 12 THEN GOTO 40010
400:             IF DAY LT 1 OR DAY GT 31 THEN 40010
400:             END
400:  40010      ERROR "ERROR IN DATE FORMAT -- USE MONTH/DAY/YEAR"
400:             CLEAR MONTH
400:             CLEAR DAY
400:             CLEAR YEAR
400:             NEXT MONTH
400:             END
```


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you'd like to use the program generator to modify your generated programs, rather than deal with them directly. Can you change one part of a program—for example, the report format or the screen input format—without having to go through the entire specification procedure again? If you change the data-file structure, will this change be automatically reflected in the programs using that file? Ideally, changes in one part of a program or file should be reflected automatically throughout.

What kind of program is generated? It varies from one product to another. The Last One produces a stand-alone BASIC program. The BASIC program is intended for use with your machine's built-in BASIC interpreter. Quic-N-Easi produces format files and procedures that can be executed only by the Quic-N-Easi run-time package.

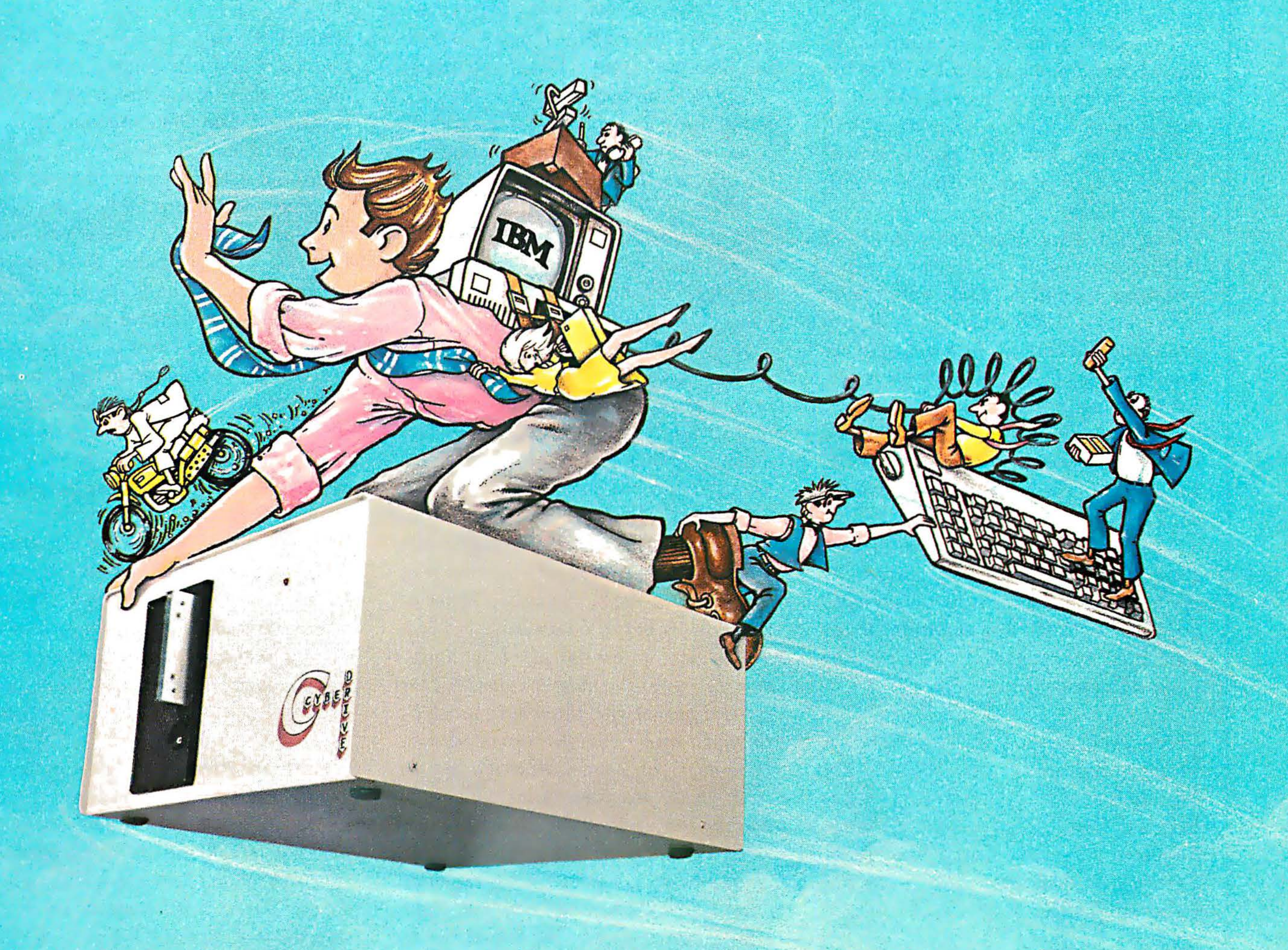
Editing convenience may be the most important aspect of a program generator.

Each approach has advantages and disadvantages. When the final program is written in a standard language like BASIC, you have more flexibility in using it. If you know the programming language, you may be able to modify the program directly. On the other hand, programs such as Quic-N-Easi that use a run-time module may be considerably faster and more efficient than BASIC programs; this applies to both program development and program use.

Is a Program Generator for You?

Even though a program generator has all the features I've mentioned, it still may not be for you. For one thing, many of the program generators assume that you know programming. Some program generators require you to learn a specification language—usually quite simple. Using such a language will require that you master at least a few elementary

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The Last One

The rather grandiose idea implicit in the product's name is that it will be the last program you ever need to buy. If that is indeed the case, the reason will probably be that you give up computing out of sheer frustration with The Last One.

The Last One is written entirely in BASIC. It consists of dozens of separate program and data files comprising more than 175,000 bytes of code (on the Model II version). In terms of sheer program size, D. J. 'AI' Systems is certainly giving you your money's worth. Of course, programs can't be rated solely in terms of cost per byte of code. Far more important is how useful the code is.

The Last One is a fully menu-driven system; that means at every stage of its operation, the screen lists currently available options. For example, when you start the program, you see the main dispersal menu:

Create program . . . . <1>
Modify program . . . . <2>
Modify file . . . . <3>
External files . . . . <4>
Enquiry . . . . <5>
Certify new disk . . . . <6>
Return to BASIC . . . . <7>

Each time you select an option, The Last One must load the appropriate program and run it. This makes the system quite sluggish. Most of your time is spent watching the computer display the message "Please wait...working." Because of a complex hierarchy of menus, skipping from one activity to another (from, for example, screen design to procedure specification) is tortuous if not impossible.

Sample Use

For generating routine data-entry applications (such as the mailing list described in the main article), The Last One is acceptable but cumbersome. You start by specifying exactly what information goes into the file. You assign a name to each field, describe the field (any characters, numeric only, or date-format data), and specify the field size. Having only three data types puts a larger burden on you to check data entries for valid information; often you will need to ensure that the data falls into a much narrower category (compare with Quic-N-Easi). If you make a mistake, you can correct it by retyping all the information for the affected field.

After describing the data, you set a "file pointer," which determines the position in the file where input/output will begin. This is probably the first place where previous computer knowledge is useful.

Next you specify the program logic in two steps. Using a "flowchart creation menu," you select the desired sequence of operations for your program. Figure 2 shows the steps used to program the mailing-list application. When you're done with the flowchart, you have a very general description of the program logic. However, most of the work is yet to be done.

The next phase is called "coding," and it's by far the most tedious. All the generalities of the flowchart must be turned into specific procedures. Wherever you have indicated a branch (change in program flow), you now specify the destination of the branch, referring back to the original flowchart. Wherever you have specified "input from keyboard" in the flowchart, you will now be prompted to design an input screen. The Last One doesn't have a full-featured screen editor, so you must locate the prompting fields using row and column numbers. To change a completed screen, you must erase it and start all over.

Wherever you have indicated calculations, The Last One will ask you to specify them as formulas. Unfortunately, you cannot use the field names but must resort to meaningless symbols like V1, V2, V3, etc.

Outputting results is similar to keyboard input: you specify the output format by relating data fields to various rows and columns on the screen. The Last One will go through the entire list of variables in your program and ask where each one of them is to be output. Typically, only a very few of them are desired as output. This means much needless effort.

When the generalities have all been reduced to specifics, The Last One will generate a BASIC program. The final result will contain routines to handle keyboard and disk-related errors. You will be able to use the program (and associated data files) independently of The Last One.

Should you ever want to modify the program, you'll probably want to use The Last One again, even if you know BASIC. The reason is that the generated program is completely undocumented. Variable names used have no meaning, and no explanatory remarks are embedded in the program. You can have a copy of the flowchart included at the beginning of the program, but that is too general to be really helpful in program modification. It's easy to modify a flowchart, and generating the flowchart isn't difficult in itself. The hard part is modifying the coded program. Rather than changing a few parts and leaving the rest of the coding unchanged, you must painstakingly repeat the entire coding procedure.

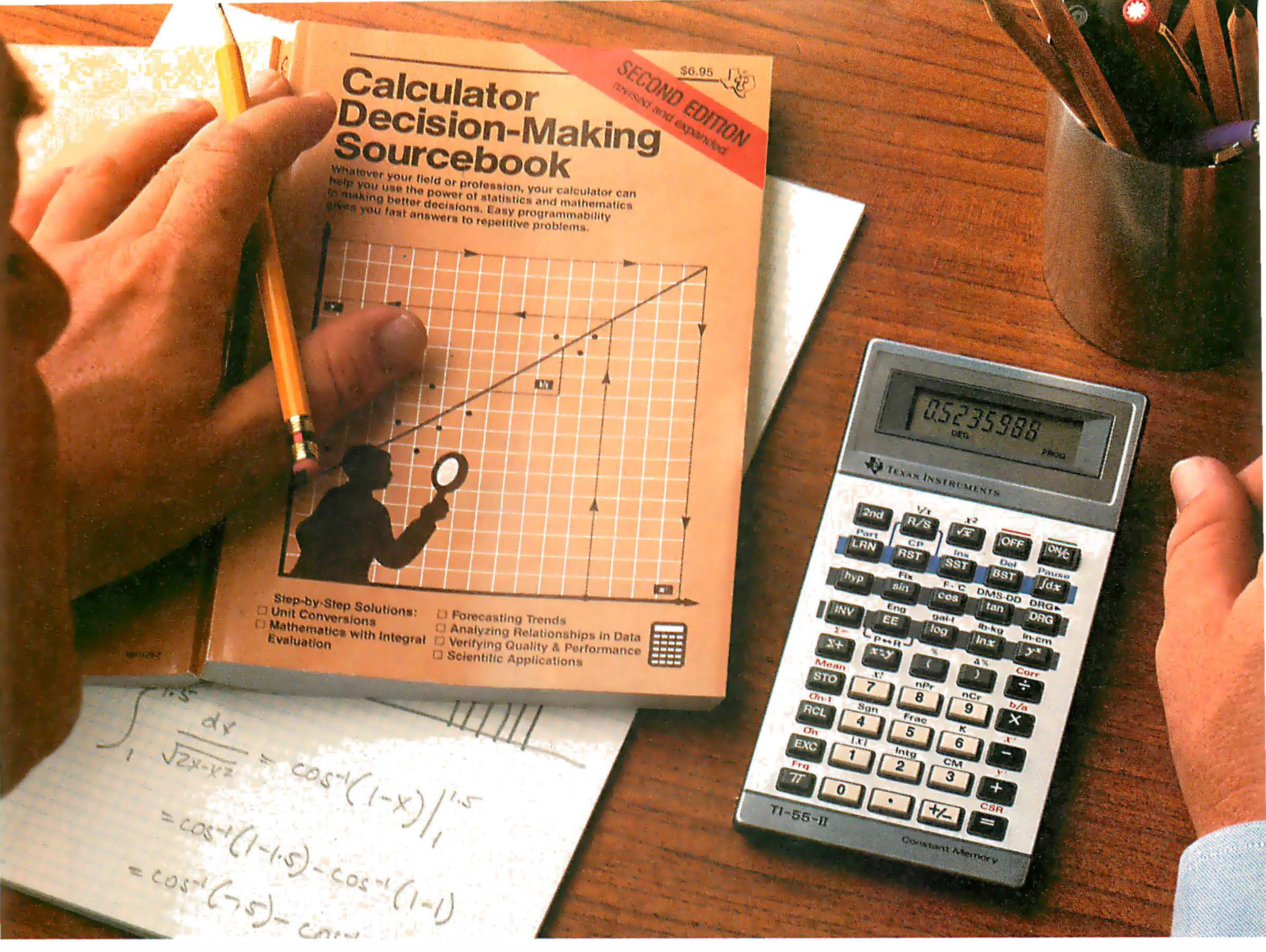
Documentation

The instruction manuals are tutorial and quite readable. One describes the package in general; the other describes specifics related to the machine you are using. The general manual takes you step by step through a simple mailing-list application, the best way to get you into the subject. However, the manual is not organized for easy reference. Information is scattered about in different sections, and much information is too abbreviated.

Summary

The Last One does contain a considerable amount of embedded knowledge. It can generate a great deal of BASIC code given a few simple commands. Unlike other program generators, The Last One doesn't require you to learn a specification language. It's a shame that the system isn't faster and easier to use.

If you are willing to wade through a tedious maze of menus and specification procedures that may take hours, and if you refuse to learn BASIC or any other programming language, you can probably find a use for The Last One, especially if your application is to perform simple data storage and retrieval. . . . **G. S.**



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TEXAS INSTRUMENTS

Circle 231 on inquiry card.

Quic-N-Easi

The instruction manual describes Quic-N-Easi as "an applications development language that dramatically reduces development time and produces more professional, clearer screen presentations." Compared to The Last One's hyperbole, this is a refreshingly modest and accurate description.

To use this product successfully, you will need to learn some programming concepts and the Quic-N-Easi language. That's going to take a while (anywhere from a day to a week or more). But once you've learned it, you have a tool that really can speed up the programming of common business applications. (If you learn the advanced features, you can go far beyond run-of-the-mill data entry and retrieval applications.)

Quic-N-Easi consists of two programs, the "format builder" and the "run-time interpreter." The format builder lets you describe the data, set up screen formats, and specify procedures in the Quic-N-Easi language. The result of this effort is called a format file and is really your application program. The run-time program interprets the format file and, in so doing, performs the application.

The striking features of Quic-N-Easi are ease of editing and logical operation. You work with only three "modes" or activities while creating a format file: building a format background (designing the screen layout), defining the data fields, and specifying program procedures. It's simple to skip from one activity to another without losing work in either area.

Sample Use

To generate the sample mailing-list application (see main article), you start by defining the screen format. Quic-N-Easi has a screen editor that makes this easy: rather than referring to screen locations with row and column numbers, you type the desired information right onto the screen. Next you locate operator-entry fields on the screen and specify what kind of data goes in each. There are nine categories of data, including various combinations of numbers, uppercase letters, and lowercase letters. This generous selection takes much of the burden of data checking from you during the procedure specification stage: the computer will automatically ensure that valid data is entered from the keyboard.

Finally, you specify procedures to be executed immediately after each field is entered or after the entire screen form is filled. Listing 2 shows the procedures used to generate the mailing-list application.

The Quic-N-Easi language is simpler than BASIC; nevertheless, it is a computer language. If it's your first, expect some difficulty. One good thing about this language is that you can always refer to your data in terms of names you choose, like ID, STREET, etc. This is true even when you're specifying calculations to be performed on these fields. Only for internal calculations do you have to resort to names like #S0, #N0, and #B0.

Disk input/output is another strong point of this product. In addition to sequential and random-access files, Quic-N-Easi offers indexed sequential files, which enable your file update programs to operate with exceptional speed. (See section entitled "File Storage" page 42.) The mailing-list application was programmed using indexed sequential files.

Documentation

The instruction manual for Quic-N-Easi contains a self-teaching guide and a programmer's reference section. The self-teaching guide uses prepared format files supplied with the software distribution disk and makes an effective introduction to the system. Mastering the system is going to take quite a while, and the programmer's reference section will become useful as you begin to grasp the principles of operation. A handy reference card is also provided.

Summary

Quic-N-Easi will not free you from the task of programming. To make full use of it, you will need to understand fundamental principles of programming—as well as learn the Quic-N-Easi language. However, once you've passed these hurdles, Quic-N-Easi should help you to generate common business-application programs much faster than could be done using BASIC or other programming languages. And the level of expertise required to create a given application with Quic-N-Easi is lower than that required to create the same application in an ordinary language. . . . **G. S.**

programming concepts and techniques.

One final point seems obvious but is often missed: to use a program generator effectively, you must fully understand the desired application. It's no use, for example, trying to make a program generator produce a double-entry ledger system if you know nothing about accounting. Even the mailing-list application requires that you have a good understanding of the best way to store data. (How many characters should be allowed for the name field, address field, etc?) Manual systems are much more flexible than computer systems in these areas; you'll probably have to do more specific planning than you're used to.

One thing's for sure. Using an application generator will give you more appreciation for the work programmers do. If using a program generator takes so much effort, think about what programmers have to go through. ■

High-Resolution Sprite-Oriented Color Graphics

You don't need Logo to use sprites for animation with the illusion of depth.

Steve Ciarcia
POB 582
Glastonbury, CT 06033

A funny thing happened on my way to writing this article. Very rarely do I ever know what BYTE's monthly theme is when I am planning a project. The editors tell me, but I am always working on so many hardware projects simultaneously that I can't keep track. And I sometimes juggle my project schedule at the last minute.

This time, three weeks before my deadline, I told Senior Editor Gregg Williams that I was designing a sprite-graphics interface for August. He reminded me that the theme of the issue was Logo and that my project was a perfect enhancement to a Logo package produced by Terrapin Inc. of Cambridge, Massachusetts.

"What's Logo?" I thought to myself, but not wishing to appear completely ignorant, I took his word for it and sent my wire-wrapped prototype board to Leigh Klotz Jr. and Patrick Sobalvarro at Terrapin. It took them less than a week to devise ways to control my sprite-graphics interface using the Logo language.

Their help came just at the right time. Since I was struggling with using assembly language to draw the pictures necessary for this article, I gratefully accepted a copy of the Terrapin MIT Logo language from them, along with the Logo routines they wrote to manipulate sprites. Using Terrapin's software, I quickly came to understand why Logo and a sprite-graphics interface are a natural combination.

The key component is the TMS9918A Video Display Processor.

But you don't have to have Logo to use the sprite-graphics board. You can approach this project either as a versatile color graphics interface that you can mold to fit your requirements or as a sprite-graphics system for use with Terrapin MIT Logo. In either case, you will not be disappointed.

The TMS9918A VDP

The key component in this month's project is an integrated circuit from Texas Instruments, the TMS9918A Video Display Processor (VDP). This chip offers features that are not, to my knowledge, found in any other graphics system. A summary of its capabilities is shown in table 1.

The TMS9918A VDP is intended to be interfaced to a host microprocessor through an 8-bit bidirectional data bus and three control lines. The VDP's output is a composite color video signal, which can be fed directly into a video monitor or, with the addition of an RF (radio-frequency) modulator, to the antenna terminals of a television set.

Up to 16K bytes of dynamic RAM (random-access read/write memory) can be attached directly to the VDP. This VRAM (video RAM), which contains the data that defines the graphics image to be displayed, is automatically refreshed by the VDP. The VRAM needs no direct connection to the host computer.

The host processor interacts with the 9918A by reading from or writing to its registers or the VRAM. The interpretation of the data flow is controlled by the states of the three control lines. The timing of register and VRAM updates is asynchronous with the video output; thus the host processor can communicate with the VDP at any time.

Certain figures and diagrams pertaining to the TMS9918A are reprinted courtesy of Texas Instruments Inc.

1. display resolution of 256 by 192 pixels
2. 16 colors, including black and transparent
3. supports 16K bytes of separate video memory
4. real-time interrupt capability
5. 32 sprites for simulation of three-dimensional effects
6. composite video output
7. four display modes:
   a. graphics I (256 by 192 dots—limited color)
   b. graphics II (256 by 192 dots—extended color)
   c. text mode (24 lines of 40 user-defined characters)
   d. multicolor mode (64 by 48 low-resolution positions)
8. external video and sync inputs
9. automatic, transparent dynamic RAM refresh

Table 1: *Characteristics of the Texas Instruments TMS9918A Video Display Processor integrated circuit.*

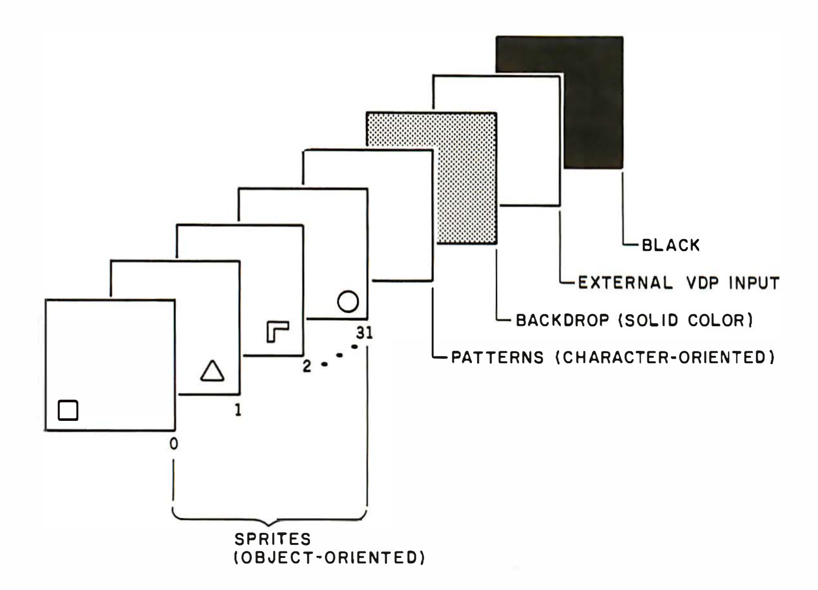


Figure 1: *The TMS9918A's screen image can be envisioned as a set of overlapping display planes sandwiched together. Image objects in planes figuratively closer to the viewer (the top layers of the sandwich) seem to be in front of objects on planes further away (the bottom layers of the sandwich). The top 32 sprite planes are in front of the pattern plane, the backdrop plane, and the external VDP (video) plane, which can contain a video image from almost any compatible external source. The 9918A combines the multiple image sources to form a single composite image.*

Distinctive Architecture

The TMS9918A VDP displays an image on the screen that can be best envisioned as a set of overlapping display planes sandwiched together, as shown in figure 1. This distinctive graphics architecture makes possible the simulation of depth relationships between animated objects in the display without the use of complex hidden-line algorithms.

Image objects in planes figuratively closer to the viewer (the top layers of the sandwich) have higher priorities of visibility than the planes further away (the bottom layers of the sandwich). When the objects on two different planes attempt to occupy the same spot on the screen, the object on the higher-priority plane will be seen by the viewer. For an object on one of the lower-priority planes to be visible, all planes in front of the object's plane (the higher-priority planes) must be transparent at that point.

The top 32 planes are designated for the display of special graphics objects called sprites, which I'll explain shortly. Behind the sprite planes is the pattern plane. The pattern plane is used for text and graphics generated in one of four color-display modes. This pattern plane works like a conventional single-plane, spriteless graphics system. The resolution varies depending on the display mode selected.

Behind the pattern plane is the backdrop plane. Its area is larger than the other planes so that it can form a border around them. The backdrop is always either 1 of 15 solid colors or transparent.

The last, rearmost plane is called the external VDP plane, which can allow one 9918A chip to overlay its display over the output of a second 9918A. But the external VDP plane could contain a video image from almost any compatible external source such as a TV camera, a videotape recorder, or another computer display, as long as the external source is synchronized to the 9918A's Clock and Reset/Sync inputs. It might also be necessary to adjust the signal voltage levels.

The four image sources (sprites, pattern plane, backdrop, and external input) can be combined to create a single composite image in the 9918A. In most applications, however, the 9918A's external VDP input is not used, and the image is formed from the pattern, backdrop, and sprite planes.

What Are Sprites?

A sprite is a graphics object of a specified pattern appearing on its plane in a position determined by a single coordinate pair specifying the

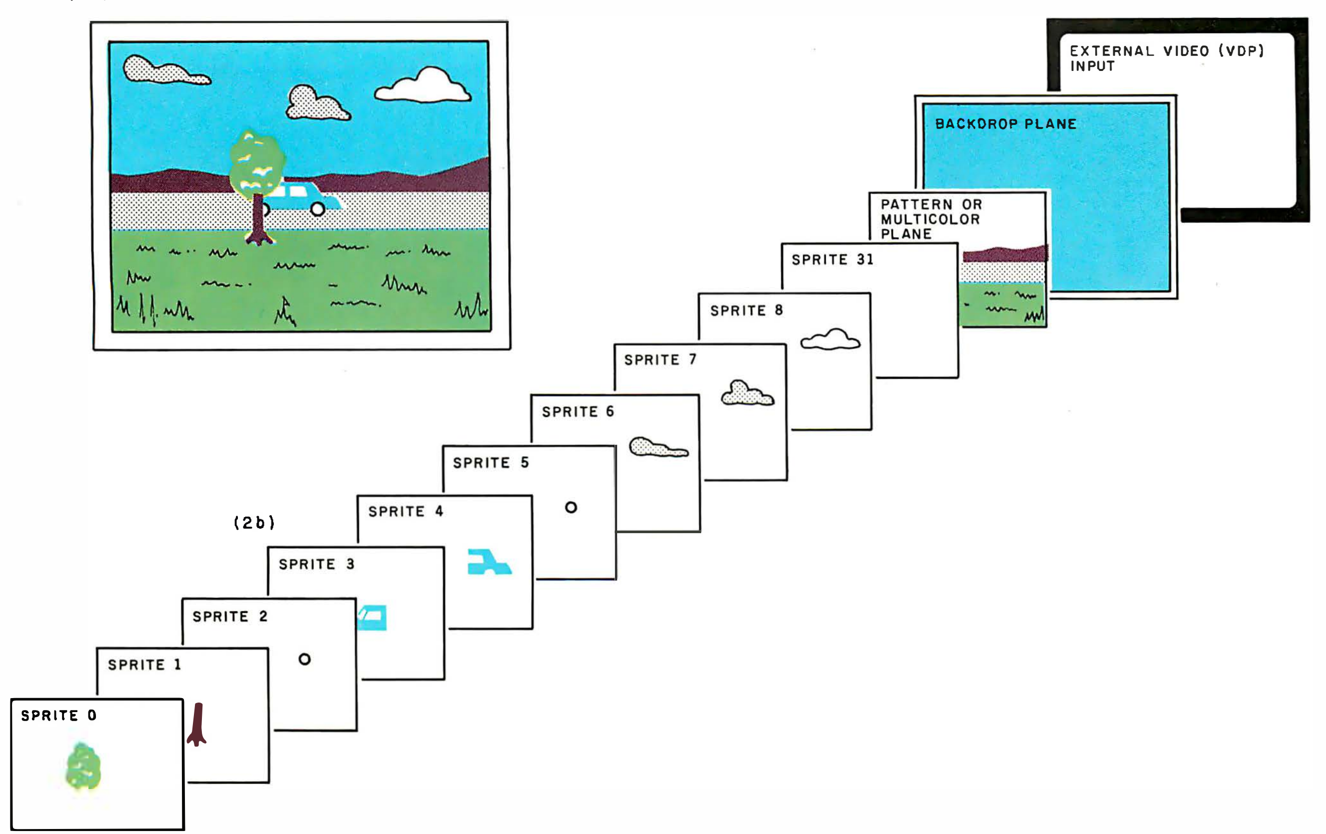


Figure 2: *A possible application for sprites: displaying a graphics image of an automobile driving along a road through hilly country, past a field containing grass and a single tree, under a sky populated by clouds.*

The background, comprising the hills, grass, road, and sky, is "painted" on the pattern plane. Sprites 0 and 1 are set up with patterns representing the tree's foliage and trunk. The sections of the car are drawn using sprites 2 through 5. Finally, three clouds are drawn using sprites 6 through 8. Each of the sprites can be made to move smoothly across the screen by continuously changing a 2-byte address pointer in the sprite-attribute table.

As sprites 2 through 5 (the car sprites) are moved past the position occupied by sprites 0 and 1 (the two tree sprites), the VDP selects the displayed pixel values at each point from the highest-priority plane that is not transparent at that point; therefore our view of the car is automatically blocked out as it passes behind the tree.

sprite's location on the screen in the horizontal and vertical axes. By changing this one set of coordinates, the sprite can be moved easily and quickly across the screen.

Sprites come in two sizes: 8 by 8 pixels (picture elements) and 16 by 16 pixels; they can be expanded to 32 by 32 pixels by using the magnification feature. Their resolution of movement is one pixel on the 192- by 256-pixel viewing area. Each sprite plane contains exactly one sprite; all the plane's area outside the sprite pattern is transparent. The sprite plane with the highest priority is identified as sprite 0, and the one with the lowest priority is sprite 31.

The ease of programming complex graphic displays through the use of sprites is the most significant feature of the TMS9918A.

Example of Sprite Use

Let's consider a possible application: displaying a graphics image of an automobile driving along a road through hilly country, past a field containing grass and a single tree, under a sky populated by clouds (see figure 2). Starting from the foreground, we see that there is a tree between our point of view and the roadway. Naturally we expect the car to be obscured by the tree when passing behind it. And the car should obscure the background hills wherever it goes.

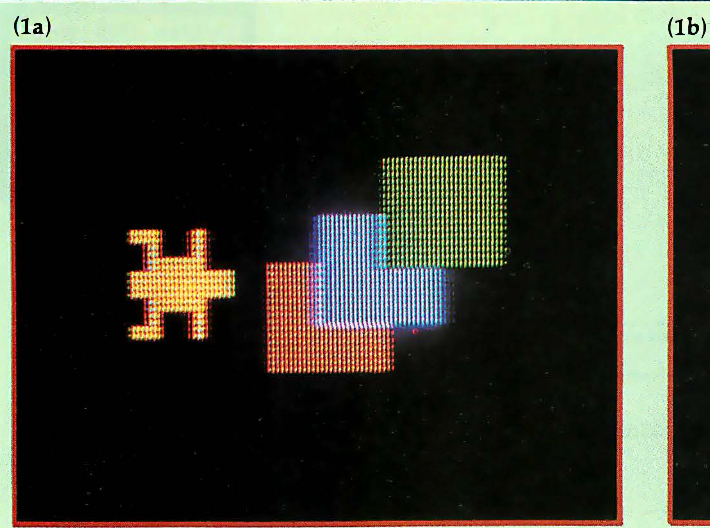
This scene is set up on the 9918A as follows. The background, comprising the hills, grass, road, and sky, is "painted" on the pattern plane in a way similar to the use of any conventional display.

Since the size of the sprites is limited and each sprite can be only one color, it sometimes becomes necessary to use multiple sprites to define a single entity in the picture. (When the entity is to be moved across the screen, all the sprites that form it must be moved at the same time.) So, following this plan, sprites 0 and 1 are set up with patterns representing the tree's foliage and trunk. The sections of the car (front and rear of the body plus the two visible tires) are drawn using sprites 2 through 5. Finally, three clouds (of slightly different colors) are drawn using sprites 6 through 8. Sprite planes 9 through 31 are left transparent.

Animation Comes Easy

Once the static display has been established, we can see why sprites are so useful in animating the display,

(1a)



(1b)

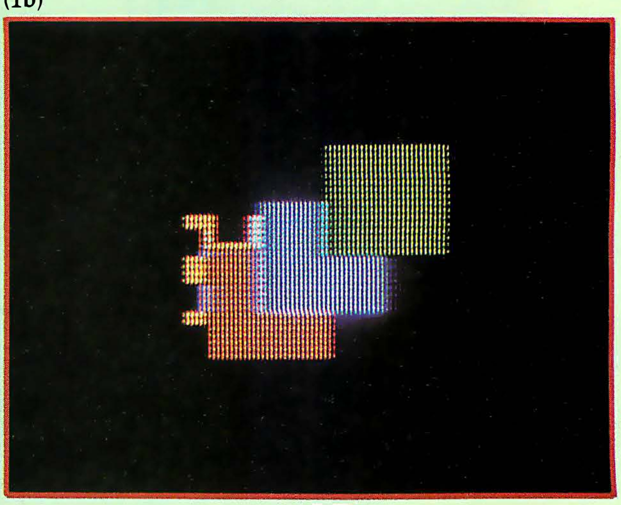


Photo 1: *A step-by-step illustration of the use of sprites and the concept of plane priority. The yellow turtle (sprite 3) is programmed to pass from left to right past the green box (sprite 0), the blue box (sprite 1), and the red box (sprite 2). The transparent pattern plane and backdrop cause the background to be black.*

that is, causing parts of it to move. What would ordinarily be an extensive programming task is handled almost entirely in hardware by the 9918A.

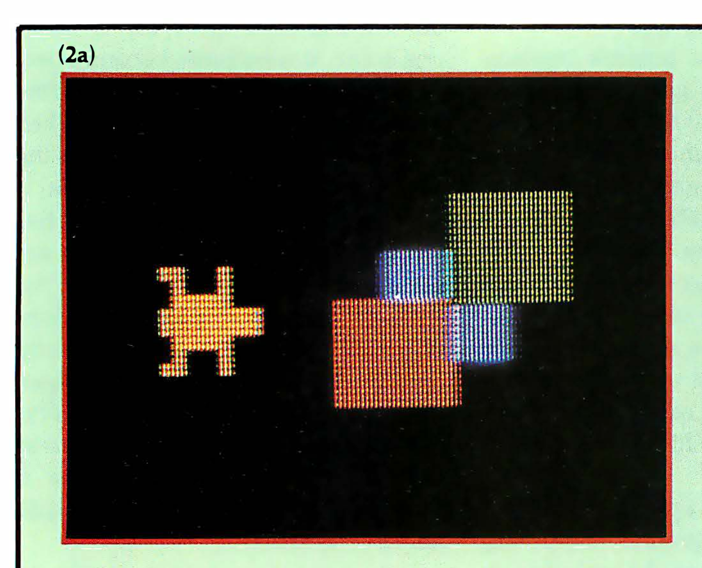
Unlike spriteless systems, moving the car does not require that the software repaint the entire display pattern. Simply by continuously changing a 2-byte address pointer in the sprite-attribute table in VRAM, each of the sprites can be made to move smoothly across the screen.

In addition, as sprites 2 through 5 (the car sprites) are moved past the position occupied by sprites 0 and 1 (the two tree sprites), the VDP selects the displayed pixel values at each point from the highest-priority plane that is not transparent at that point; therefore our view of the car is automatically blocked out as it passes behind the tree. Similarly, if the clouds are different colors (perhaps white and gray) and made to pass each other, they will also appear to pass in front or behind in a pseudo-three-dimensional view. This hidden-view capability is provided in hardware and requires no special software, unlike conventional graphics systems.

Additional Examples

Photo sequences 1 and 2 are step-by-step illustrations of the use of

(2a)



(2b)

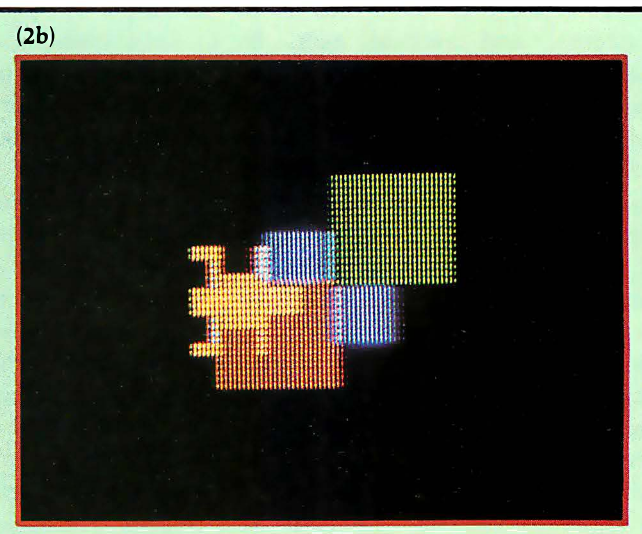
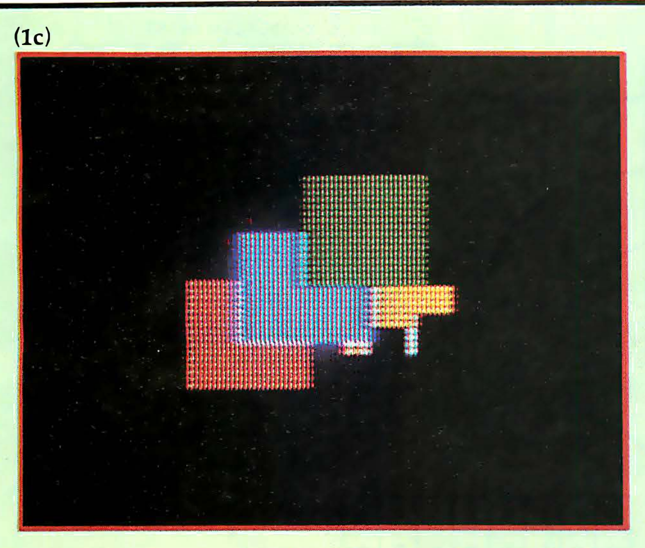
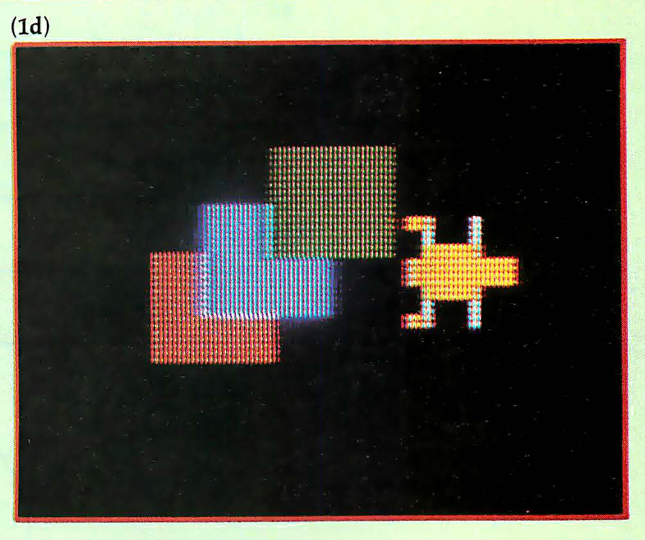


Photo 2: *Some priorities have been exchanged from photo 1: the shapes have been set up on a new permutation of planes. The green and red boxes remain sprites 0 and 2, respectively, but the turtle is now sprite 1 and the blue box is sprite 3. The boxes now overlap in a different order; instead of the sequence green, blue, red, we now have green, red, blue.*

(1c)



(1d)



The turtle is obscured from view as it passes from left to right past the three boxes, beginning in photo 1b. It is not fully visible until it emerges again on the right in photo 1d. Since the three boxes reside on sprite planes of higher priority than the turtle's plane, the pixel values of the boxes take precedence in being displayed wherever the sprite shapes intersect. Also, the three boxes overlap according to their planes' priorities.

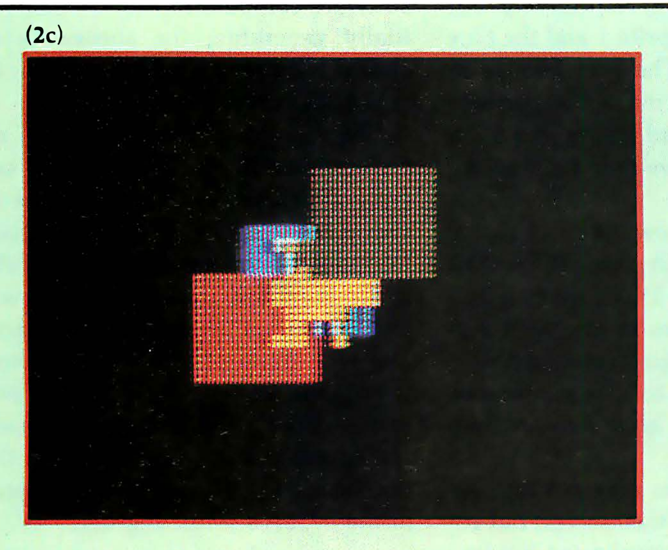
sprites and the concept of plane priority. Both examples use four sprites, but the priorities of the planes used for each sprite shape are changed to demonstrate different effects. Three of the sprites are solid-color boxes, and one is a shape described as a turtle. The turtle is programmed to pass from left to right past the boxes.

In photos 1a through 1d, the green box is sprite 0, the blue box is sprite 1, and the red box is sprite 2. The yellow turtle is sprite 3. No other sprites are involved, and the pattern plane and backdrop are transparent, resulting in a black background.

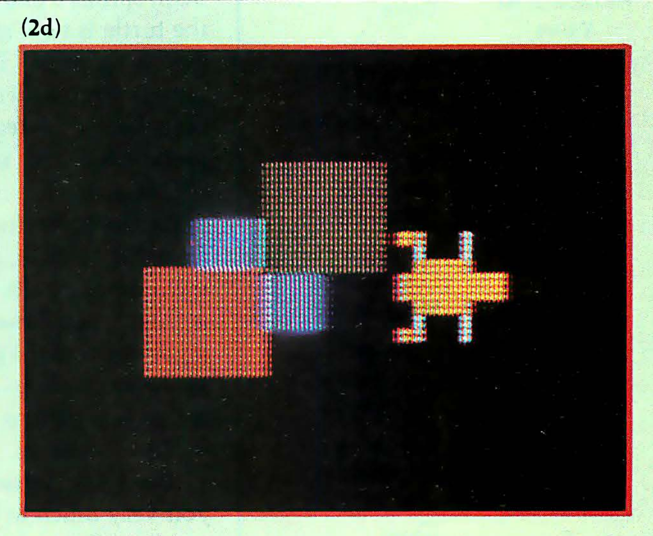
You'll notice that the turtle is obscured from view as it passes from left to right past the three boxes, beginning in photo 1b. Since the three boxes reside on sprite planes of higher priority than the turtle's plane, the pixel values of the boxes take precedence in being displayed wherever the sprite shapes intersect. Observe also that the three boxes overlap according to their planes' priorities. The green covers the blue, and the blue covers the red. As for the turtle, it has the lowest priority and is not fully visible until it emerges again on the right in photo 1d.

In photos 2a through 2d, some priorities are exchanged: the shapes have been set up on a new permutation of planes. The green and red boxes re-

(2c)



(2d)



As the turtle (now sprite 1) passes from left to right, it passes in front of the red box (sprite 2) and the blue box (sprite 3), as shown in photo 2b, but it goes behind the green box (sprite 0), in photo 2c.

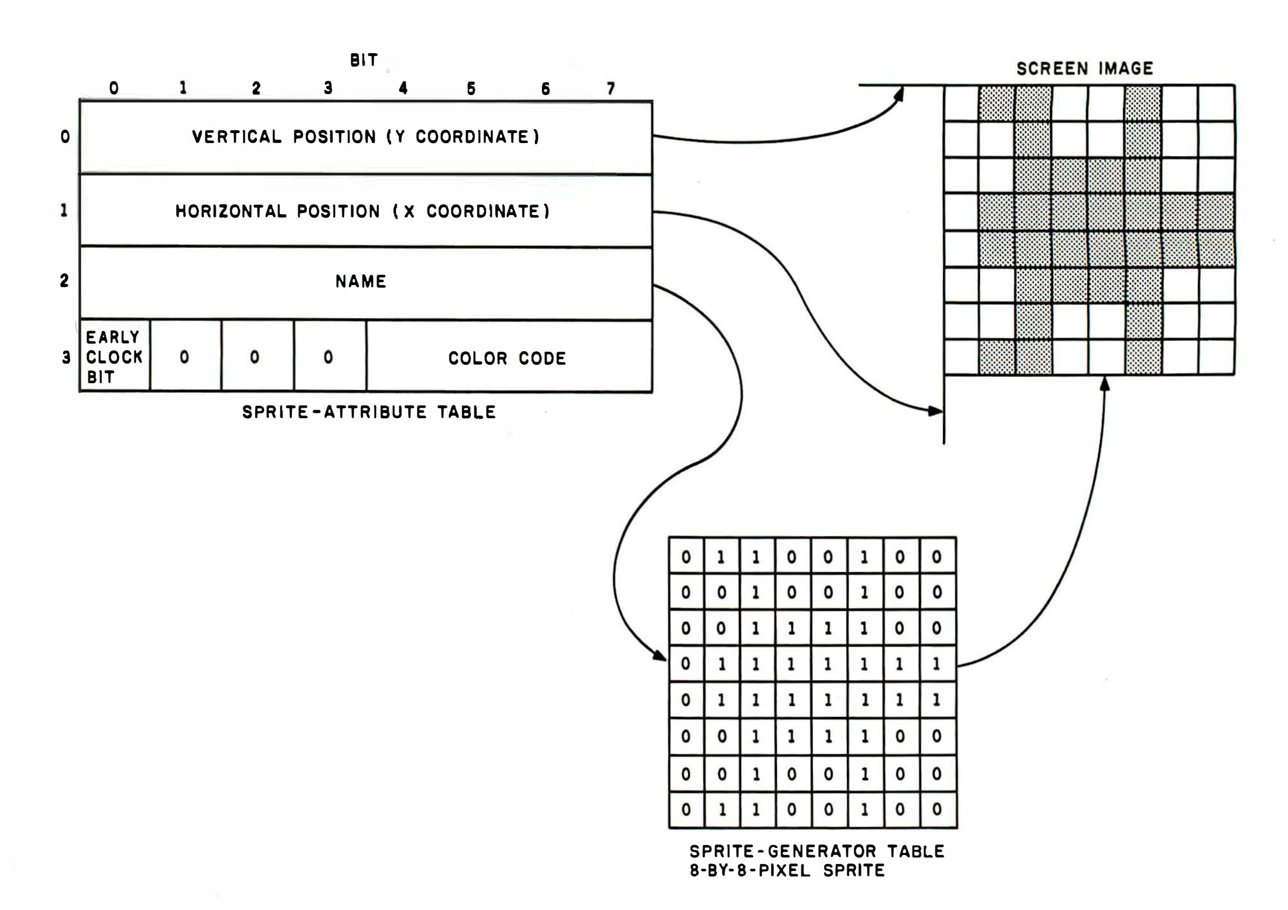


Figure 3: *The binary coding for an 8-by-8-pixel sprite pattern is stored in VRAM in the sprite-generator table in 8 bytes. Each bit in the pattern coding corresponds to one pixel in the displayed pattern. Wherever a 1 is stored in a pixel's pattern bit, the sprite will be colored; where the bit is a 0, the sprite will be transparent. Each sprite can be only a single color.*

Each sprite's attributes are stored in the 128-byte sprite-attribute table. Each set of attributes takes up 4 bytes. In each set of attributes, the first two bytes set the x,y coordinates of the sprite on the screen, referenced from the screen's upper left corner. The third attribute byte contains the sprite's "name" (actually the low-order bits of the address of its segment of the sprite-generator table), and the fourth byte defines the sprite's color, according to the 4-bit color values given in table 2.

Hexadecimal Value	Color
0	transparent
1	black
2	medium green
3	light green
4	dark blue
5	light blue
6	dark red
7	cyan
8	medium red
9	light red
A	dark yellow
B	light yellow
C	dark green
D	magenta
E	gray
F	white

Table 2: *Four-bit binary codes used by the 9918A to specify the color of a picture element or color pattern.*

main sprites 0 and 2, respectively, but the turtle is now sprite 1 and the blue box is sprite 3. The first feature of note is the reordering of the overlapping boxes. Instead of the sequence green, blue, red, we now have green, red, blue.

As the turtle (now sprite 1) passes from left to right, it passes in front of the red box (sprite 2) and the blue box (sprite 3), as shown in photo 2b, but it goes behind the green box (sprite 0), as we see in photo 2c. The appearance is that it is passing among rather than behind the boxes.

Boxes and turtles may not impress you very much in themselves, but remember that no complicated hidden-line algorithms are needed to determine pixel precedence. Everything I've demonstrated is done completely in hardware on the 9918A. The only software computation (other than initially generating the sprites) is to change a 2-byte *x,y* coordinate pair to move the turtle.

There is a restriction, however, on the number of sprites that may occupy a single horizontal scan line in the video display raster: only four may do so simultaneously. If a fifth sprite is moved into a position such that part of its pattern is on the same line with parts of four other sprites, the conflicting parts of the *lowest priority* sprite of the five will be made transparent on the display. Also, the number of the fifth sprite will appear in the 9918A's status register.

Structure of Sprites

There are two basic sizes of sprites: 8 by 8 pixels and 16 by 16 pixels. The 8- by 8-pixel sprite is more often used;

the binary coding for its pattern is stored in VRAM in the *sprite-generator table* (SGT) in 8 bytes, as shown in figure 3. The larger 16- by 16-pixel sprite requires 32 bytes for storage of its pattern coding.

Each bit in the SGT pattern coding corresponds to one pixel in the displayed pattern. Wherever a 1 is stored in a pixel's pattern bit, the sprite will be colored; where the bit is a 0, the sprite will be transparent. Each sprite can be only a single color.

Either size sprite may be enlarged (magnified) by a factor of 2 under software control; the magnification factor (1 or 2) is global, affecting all sprites. The display produced for the priority demonstration of photo sequences 1 and 2 consisted of 16- by 16-pixel sprite shapes made from 8- by 8-pixel sprites magnified to be twice as big as normal.

Each sprite's attributes (values that determine the characteristics of color, coordinate position, and SGT pattern location) are stored in the *sprite-attribute table*, or SAT, in VRAM. Each set of attributes takes up 4 bytes; to support 32 sprites, the table must be 128 bytes long. To find the storage location of a particular sprite's attributes, we merely take the sprite's number, multiply it by 4, and add the result to the base address of the sprite-attribute table, which is stored in the 9918A's register 5.

In each set of attributes, the first two bytes set the x,y coordinates of the sprite on the screen, referenced from the screen's upper left corner. The third attribute byte contains the sprite's "name" (actually the low-order bits of the address of the sprite's SGT segment), and the fourth byte defines the sprite's color, according to the 4-bit color values given in table 2.

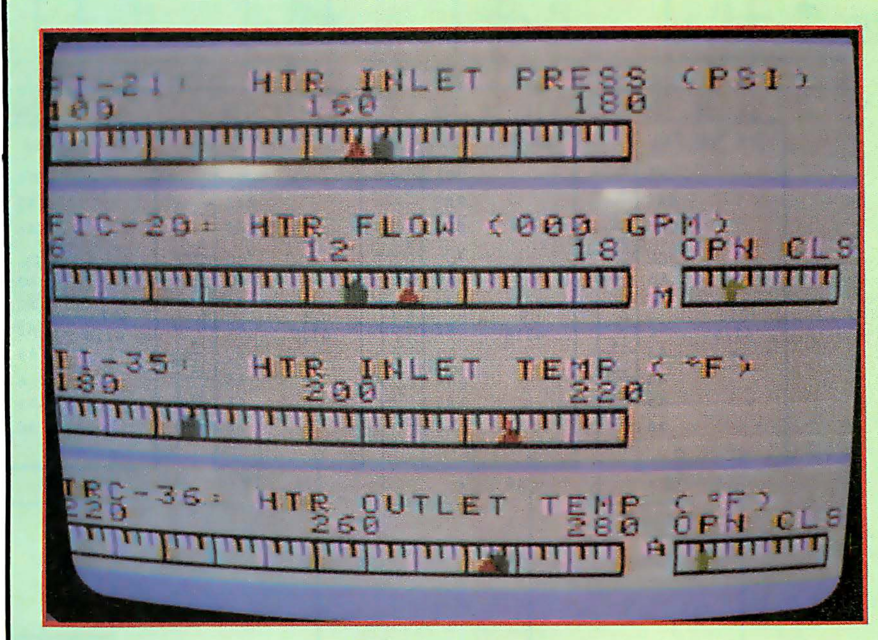


Photo 3: *A Graphics-II-mode display combined with sprites, showing a simulation of some analog sensor meters. The pattern plane contains the meter scales and alphanumeric labeling, while the pointers within the meter scales are sprites, which are easily moved to represent changes in the measured quantities.*

Not Only Sprites

In addition to sprites, the TMS9918A VDP is capable of considerable graphic feats using only the pattern plane, which operates in any of four display modes. Not all modes use the full 16K-byte memory capacity that the 9918A is capable of supporting. The display mode and memory allocation are selected by setting bits in the VDP's registers. Let's look at some of these other methods of display.

Graphics I Mode

In the Graphics I mode, the screen is divided up into a grid of pattern positions arranged in 24 rows of 32 columns: a total of 768 positions. Each pattern position contains 64 pixels arranged in 8 rows of 8 columns. The contents of the pattern-generator table (PGT) in VRAM determine what is displayed in these pattern positions, and the pattern-color table (PCT) defines the colors associated with them.

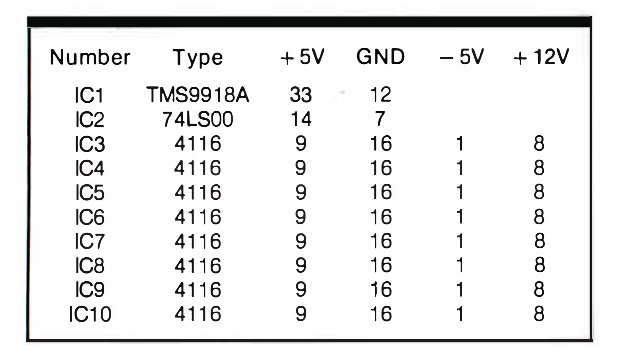
The ease of programming complex graphic displays through use of the sprites is the most significant feature of the TMS9918A.

In Graphics I mode, up to 256 different patterns can be stored; any one of these can be used in any of the 768 pattern positions, and each pattern can contain two of fifteen possible colors. The patterns can be alphanumeric characters or small sections of a large display picture, disassembled as if it were a jigsaw puzzle.

The pattern definition in the pattern-generator table consists of an 8-byte segment of memory; each bit in the segment corresponds to one pixel in the 8 by 8 matrix; the first byte is the top row of the matrix, and the second byte is the second row, etc. The colors to be used in a given pattern are determined by the two 4-bit values stored in the pattern's color byte in the pattern-color table; binary 1s and 0s are set in the pattern-generator table to turn on one color or the other for each pixel in the pattern.

Graphics II Mode

The Graphics II mode is similar to the Graphics I mode except that it allows 768 separate pattern definitions instead of only 256. In addition, instead of only two colors within each 8- by 8-pixel pattern block, Graphics II mode allows two colors to be defined separately for each byte in the pattern block, so potentially sixteen colors could appear in a single



Number	Type	+5V	GND	−5V	+12V
IC1	TMS9918A	33	12		
IC2	74LS00	14	7		
IC3	4116	9	16	1	8
IC4	4116	9	16	1	8
IC5	4116	9	16	1	8
IC6	4116	9	16	1	8
IC7	4116	9	16	1	8
IC8	4116	9	16	1	8
IC9	4116	9	16	1	8
IC10	4116	9	16	1	8

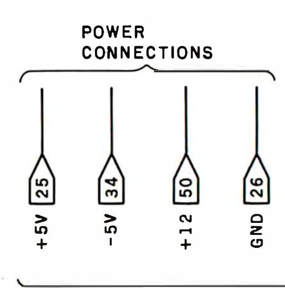


Figure 4: *A schematic diagram of the E-Z Color Graphics Interface. Very few components are needed to connect the TMS9918A to the computer's electrical bus; most of the integrated circuits are simply memory components used as the 9918A's VRAM.*

block. As you might expect, this mode uses more memory, potentially as much as 12K bytes of VRAM.

By allowing 768 distinct patterns for the 768 available pattern locations, the Graphics II mode equals the image capacity of the widely used conventional 256- by 192-pixel displays. Virtually any scene pictured in the Apple II high-resolution graphics mode, for example, can be recreated on the pattern plane of the 9918A. With a little additional application programming to set register pointers and load the pattern and color tables, the Graphics II mode can exactly synthesize the point- and line-plotting functions of conventional graphics interfaces. And you still can use the sprites.

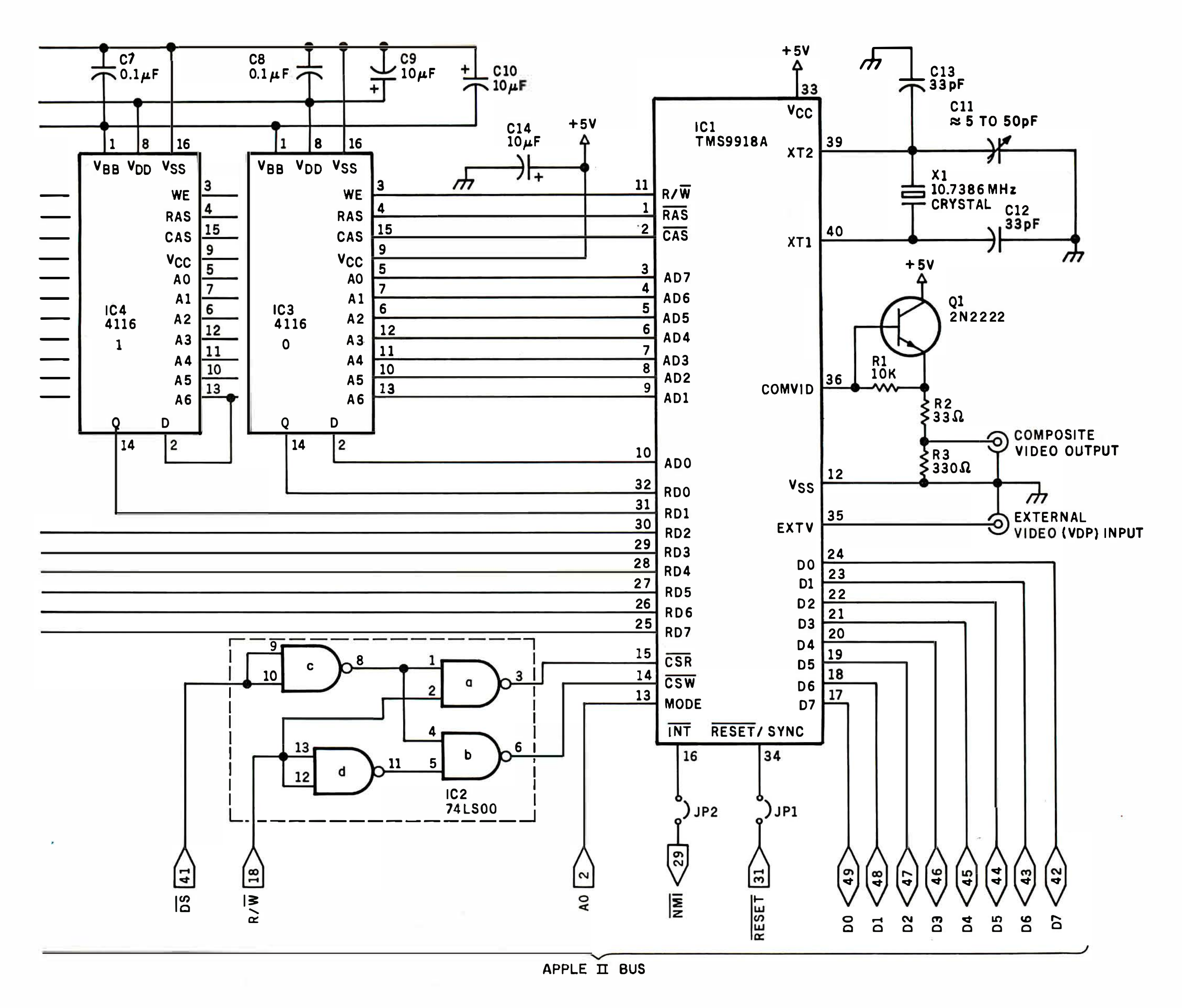
Photo 3 is an example of a Graphics-II-mode display combined with sprites, showing a simulation of some analog sensor meters. The pattern plane contains the meter scales and alphanumeric labeling, while the pointers within the meter scales are sprites, which are easily moved to represent changes in the measured quantities. Since there is no screen rewriting required to move the dial pointers, there is absolutely no flicker, and the pointer placement is an easily calculated *x* displacement.

Multicolor Mode

The Multicolor mode is essentially a low-resolution graphics mode. In it, the screen is divided into 3072 blocks, each measuring 4 by 4 pixels, in a 48-line by 64-column format. The color of each block can be any of the fifteen colors or transparent.

Text Mode

In the Text mode, the screen is divided into a grid measuring 24 lines by 40 columns of pattern positions,



The circuit shown is intended for use with an Apple II computer, with the circuit board plugged into a slot on the motherboard (usually slot 4), but other versions of the circuit for S-100-bus computers and the IBM Personal Computer are under development. The E-Z Color Graphics Interface may also be adapted for use with other computers.

each of which measures 6 by 8 pixels. The Text mode is intended for display of alphanumeric characters rather than graphics patterns. There can be up to 256 unique character patterns defined at a single time to fill the 960 pattern positions. The sprite planes are not available in Text mode. (If you need both sprites and text simultaneously, you can generate character patterns in the Graphics I mode if you don't mind a slightly shorter line length than in the Text mode.)

The character set is stored in the pattern table in VRAM. Since the cells measure 6 by 8 pixels, the characters should occupy a 5- by 7-pixel format to allow some space between characters. By properly setting the register pointers, it is possible to have the table addresses for the character patterns equal the characters' ASCII (American Standard Code for Information Interchange) values, which makes character generation easy.

Use of Memory

While the 9918A project I built has 16K bytes of VRAM, not all modes use that much. A typical application that uses only two colors with 256 unique 8- by 8-pixel patterns and 32 sprites would take less than 4K bytes of VRAM. By providing 16K bytes of VRAM with the 9918A, I found that I often had room to store four complete displays; the VDP can switch between them by simply changing pointers in the registers.

E-Z Color Graphics Interface

Figure 4 is the schematic diagram of my project for this month, which I call the Circuit Cellar E-Z Color Graphics Interface. The design is a typical 9918A color graphics interface in that it is interfaced to a microcomputer bus with a minimum of compo-

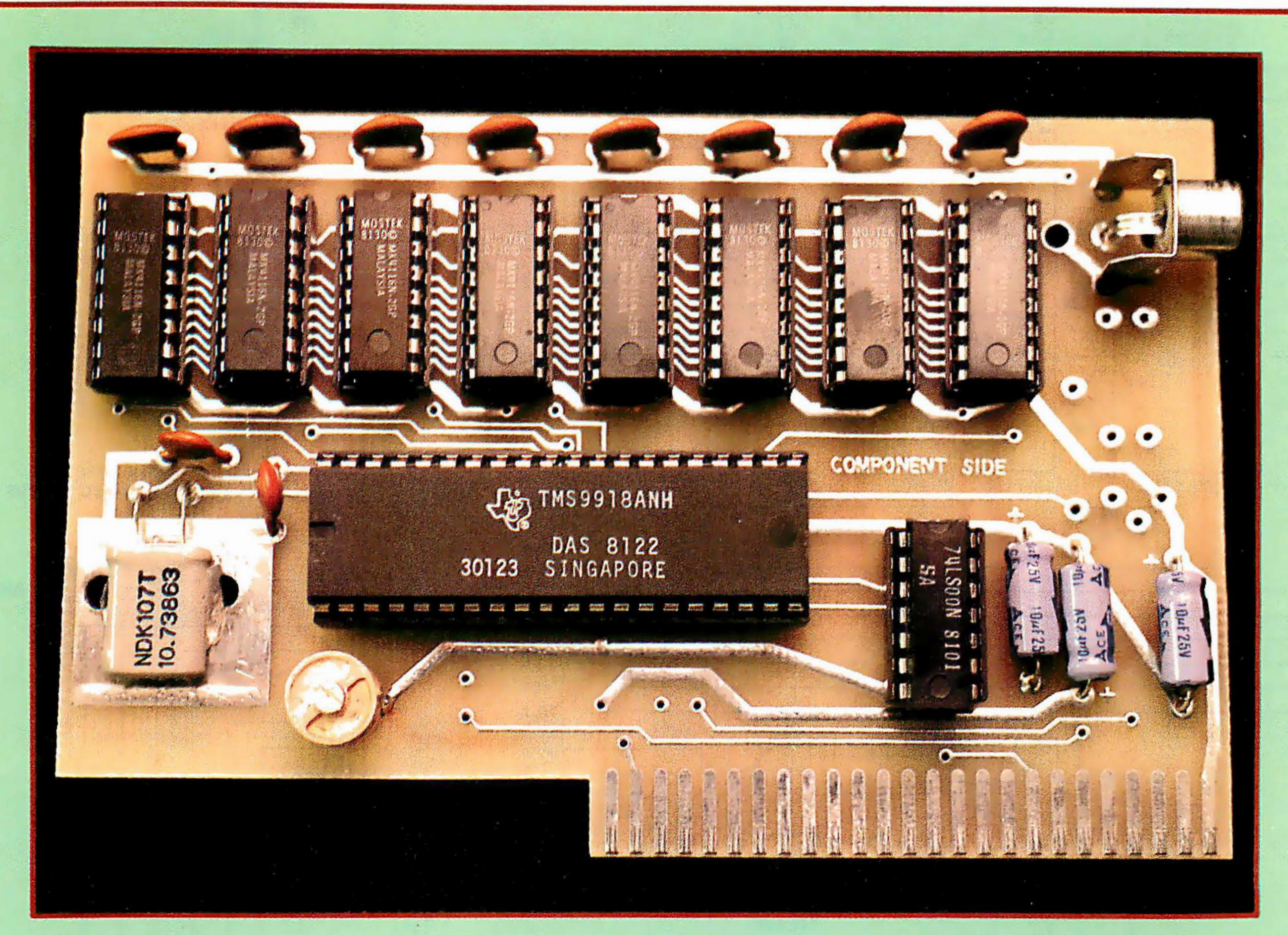


Photo 4: *The Circuit Cellar E-Z Color Graphics Interface; a prototype printed-circuit board is shown. This typical TMS9918A color graphics interface is interfaced to the Apple II microcomputer bus with a minimum of components.*

nents. A prototype printed-circuit board is shown in photo 4.

This particular design has been configured for use with an Apple II, yet its signals are compatible with those used in many other computer systems. If you are willing to add a 40-pin connector and do some hand-wiring, you can use this board with some other kind of microcomputer.

The circuit requires an 8-bit bidirectional data bus, one address line (typically A0), and the two control signals Read Enable (CSR) and Write Enable (CSW). For operation with the Apple II, these signals are formed by logically combining the Apple's DS (Device Select) and R/W (Read/Write) lines. The two control signals are known by different names in other computer systems, but their functions are generally compatible. Two additional lines, INT (Interrupt) and Reset/Sync, are shown as jumper connections. They are available for various optional enhancements, such as interrupt-driven animation or synchronization with external video sources.

By the time you read this article, I shall have completed the designs for S-100-bus and IBM Personal Computer versions of the E-Z Color interface. Check with the parts source given at the end of the article for availability.

Assembly-Language Sprite Use

As I alluded before, the 9918A is initialized by loading values into control bits and address pointers in eight write-only registers. Drawing and moving sprites across the screen is simply a matter of choosing the proper register parameters and changing the pointers.

Listing 1 on page 68 is a program that demonstrates the routines needed to display and move sprites. The program is written in 6502 assembly language to run on an Apple II computer equipped with the E-Z Color Graphics Interface, installed in motherboard slot 4 at hexadecimal address C0C0.

The first requirement is to initialize the eight registers and clear the VRAM. In this example the 9918A is set to the following operating specifications: Graphics II mode, external video input disabled, and 16- by 16-pixel sprites, with selectable magnification to twice the normal size (32 by 32 pixels) under keyboard control.

When the program starts, four different sprites are displayed, as shown in photo 5. You can change the display as follows. When you press the M key, the sprites' position coor-

dinates are incremented and the sprites move. Pressing the O key and then a hexadecimal digit 1 through F will set one of the fifteen background colors or transparency (shown). Pressing the left- or right-arrow keys will vary the sprites' size between 16 by 16 and 32 by 32 pixels.

If you are ambitious, one possible exercise is to add more sprites to this program. Photo 6 shows how complicated things get when we have 24 sprites.

Logo Sprite Use

If you don't care to concern yourself with the intricacies of assembly language, you may choose to use routines written in Terrapin's version of MIT Logo to control the E-Z Color graphics.

Terrapin Logo normally uses a single video monitor for all its display functions: text listings and line drawing. The colors available are limited to the six supported by the Apple's high-resolution graphics mode. When the E-Z Color Graphics Interface is installed, the regular display screen is still used for text display and the regular turtle graphics; the E-Z Color board must be connected to a second color video monitor for its display to be simultaneously visible. Photo 7 on page 68 shows the two-monitor setup. (If you don't need to see both displays at once, you could set up a switch to select the video output of one source or the other for display on a single monitor.)

The Logo procedures developed by Leigh and Pat implement user commands to specify the characteristics of each sprite; these commands include SETSHAPE, SETCOLOR, and SXY (for "set x,y position"). If you like, you can map out your own sprite shapes and incorporate them into the routines, but some predefined patterns, shown in photo 8, are provided. (People from Terrapin seem to like turtle shapes.)

The photo sequences 1 and 2 used earlier to demonstrate sprite planes were done using a Logo program. For example, the three boxes (shown in photo 9) are drawn in Logo using the following groups of simple statements:

Text continued on page 80

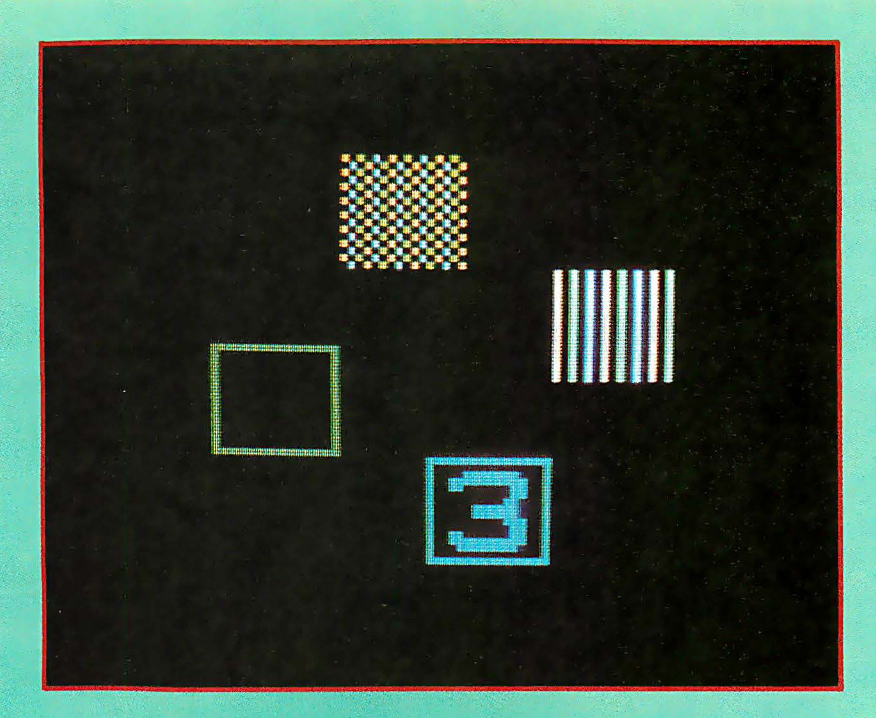


Photo 5: *Display of four sprites produced by the 6502 assembly-language program of listing 1. The user can change the display in the following ways. Pressing the M key causes the sprites to move. Pressing the O key and then a hexadecimal digit 1 through F sets one of the fifteen background colors or transparency (shown). Pressing the left- or right-arrow keys varies the sprites' size between 16 by 16 and 32 by 32 pixels.*

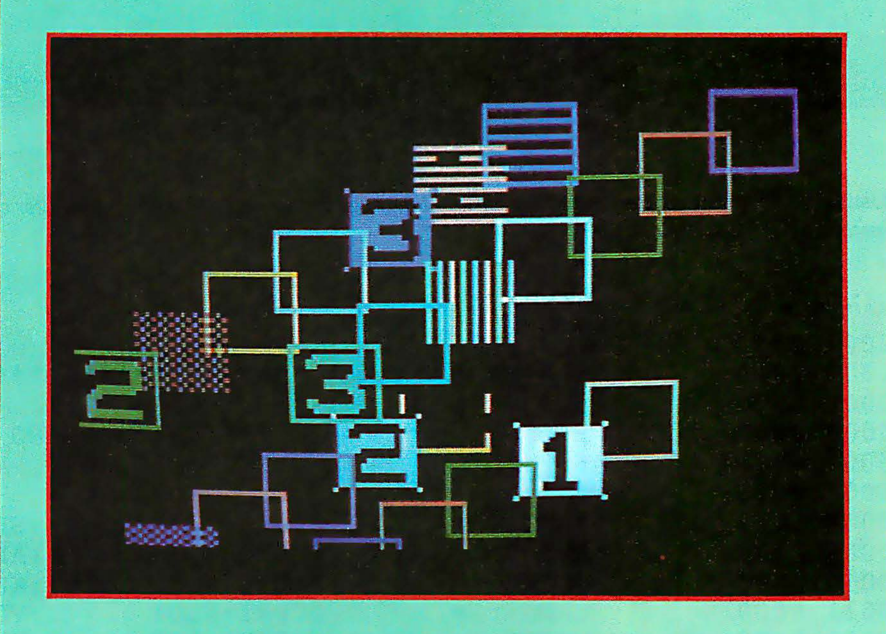


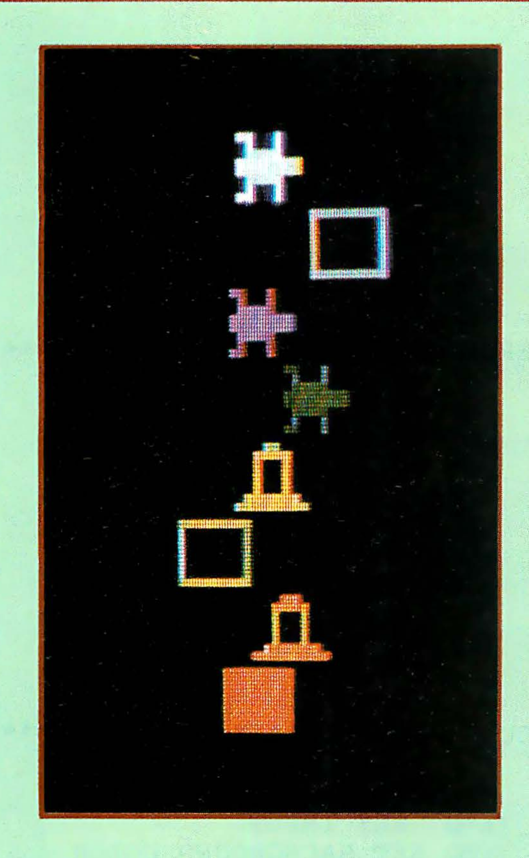
Photo 6: *The display can get complicated when 24 sprites are visible.*



Photo 7: *When the E-Z Color Graphics Interface is installed in the Apple II, the regular display screen is still used for Terrapin MIT Logo's text display and turtle graphics; the E-Z Color board must be connected to a second color video monitor for its display to be simultaneously visible.*

Listing 1: *Program written in 6502 assembly language to run on an Apple II computer equipped with an E-Z Color Graphics Interface installed in motherboard slot 4.*

```
LOC  CODE    LINE
0000         ;
0000         ;*************************************************************
0000         ;
0000         ;                    ***  VIDEO DEMO  ***
0000         ;
0000         ;
0000         SLOT    =       $40             ;SLOT = NO. X 10 HEX
0000         KBD     =       $C000           ;APPLE KEYBOARD DATA
0000         KSTRB   =       $C010           ;KEYBOARD DATA CLEAR
0000         VREG    =       $C081+SLOT      ;VDP REGISTER
0000         VDATA   =       $C080+SLOT      ;VDP RAM
0000         ;
0000                 *=       $1000           ;PROGRAM STARTING ADDRESS
1000         ;
1000         ;****************  INITIALIZE VDG  *************************
1000         ;
1000 A087            LDY #$87                ;REGISTER SELECT
1002 A207            LDX #$07                ;INITIALIZE COUNTER
1004 BDC610  INIT1   LDA ITAB,X              ;LOAD INIT TABLE
```



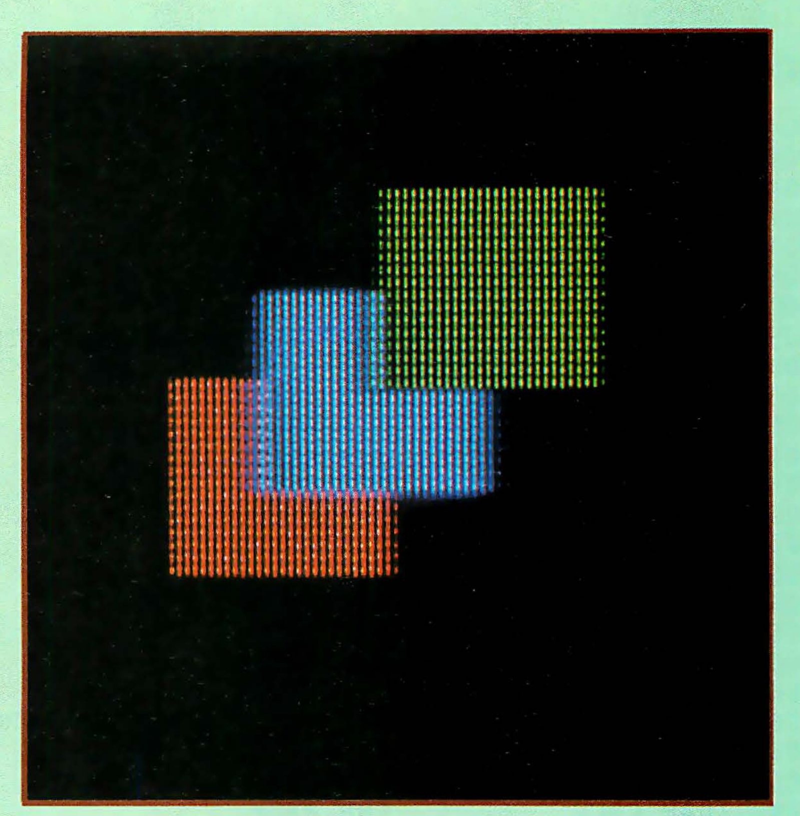


Photo 8: *The Logo procedures developed at Terrapin Inc. provide you with commands such as SETSHAPE, SETCOLOR, and SXY. You can map out your own sprite shapes and incorporate them into the routines, but some predefined patterns are provided, including a box, a rocket, a turtle, and a block.*

Photo 9: *Each of the three boxes is drawn and placed in position with only four Logo statements.*

Listing 1 continued:

```
1007 209F10        JSR SREG              ;WRITE TO VDP
100A 88            DEY                   ;DECREMENT REGISTER
100B CA            DEX                   ;DECREMENT COUNTER
100C D0F6          BNE INIT1             ;DONE?
100E          ;
100E          ;**************  CLEAR ALL MEMORY  *************************
100E          ;
100E A040          LDY #$40              ;BYTE2 ADDRESS SET UP
1010 A900          LDA #$00              ;BYTE1 ADDRESS SET UP
1012 209F10        JSR SREG              ;WRITE TO VDP
1015 A2C0          LDX #$C0              ;COUNTER HIGH BYTE
1017 A000     NEXF LDY #$00              ;COUNTER LOW BYTE
1019 8DC0C0   FILL STA VDATA             ;WRITE TO VDP RAM
101C C8            INY                   ;INCREMENT LOW COUNTER
101D D0FA          BNE FILL              ;LOW COUNTER FULL?
101F E8            INX                   ;INCREMENT HIGH COUNTER
1020 D0F5          BNE NEXF              ;HIGH COUNTER FULL?
1022          ;
1022          ;********  LOAD SPRITE ATTRIBUTES  *************************
1022          ;
1022 A047     LOOP LDY #$47              ;BYTE2 AT 0700 HEX
1024 A900          LDA #$00              ;BYTE1 ADDRESS SET UP
1026 209F10        JSR SREG              ;WRITE TO VDP
1029 A200          LDX #$00              ;INITIALIZE COUNTER
```

Listing 1 continued on page 70

Listing 1 continued:

```
LOC  CODE    LINE

102B BDCE10 NEXA    LDA ATAB,X          ;LOAD ATTRIBUTE
102E 8DC0C0         STA VDATA           ;STORE TO VDP RAM
1031 E8             INX                 ;INCREMENT COUNTER
1032 8A             TXA
1033 C910           CMP #$10            ;TEST COUNTER
1035 D0F4           BNE NEXA            ;DONE?
1037                ;
1037                ;********** LOAD SPRITE PATTERNS *************************
1037                ;
1037 A040           LDY #$40            ;BYTE2 AT 0000 HEX
1039 A900           LDA #$00            ;BYTE1 ADDRESS SET UP
103B 209F10         JSR SREG            ;WRITE TO VDP
103E A200           LDX #$00            ;INITIALIZE COUNTER
1040 BDDE10 NEXTS   LDA PTAB,X          ;LOAD PATTERN BYTE
1043 8DC0C0         STA VDATA           ;STORE TO VDP RAM
1046 E8             INX                 ;INCREMENT COUNTER
1047 8A             TXA
1048 C980           CMP #$80            ;TEST COUNTER
104A D0F4           BNE NEXTS           ;DONE?
104C                ;
104C                ;************* CHANGE BACKGROUND *************************
104C                ;
104C AD00C0 CBACK   LDA KBD             ;TEST FOR
104F C9CF           CMP #$CF            ;"O" KEY INPUT
1051 D008           BNE CSIZE           ;TO SET BACKGROUND COLOR
1053 20A610         JSR LOADN           ;READ KEYBOARD
1056 A087           LDY #$87            ;BYTE1 REGISTER 7
1058 209F10         JSR SREG            ;STORE TO VDP
105B                ;
105B                ;******************* CHANGE SIZE *************************
105B                ;
105B AD00C0 CSIZE   LDA KBD             ;TEST FOR LEFT ARROW
105E C988           CMP #$88            ;MAGNIFICATION X 1
1060 D00A           BNE ONE
1062 ADC710         LDA ITAB+1          ;LOAD REGISTER 1
1065 29FE           AND #$FE            ;MASK 0 ON LSB
1067 A081           LDY #$81            ;BYTE1 REGISTER 1
1069 209F10         JSR SREG            ;STORE TO VDP
106C C995   ONE     CMP #$95            ;TEST FOR RIGHT ARROW
106E D00A           BNE MOVE            ;MAGNIFICATION X 2
1070 ADC710         LDA ITAB+1          ;LOAD REGISTER 1
1073 0901           ORA #$01            ;MASK 1 ON LSB
1075 A081           LDY #$81            ;BYTE1 REGISTER 1
1077 209F10         JSR SREG            ;STORE TO VDP
107A                ;
107A                ;****************** MOVE SPRITES *************************
107A                ;
107A AD00C0 MOVE    LDA KBD             ;MOVE?
107D C9CD           CMP #$CD            ;TEST FOR "M" KEY
107F D018           BNE JUMP
1081 EECE10         INC ATAB            ;SPRITE0 UP
1084 CECF10         DEC ATAB+1          ;SPRITE0 LEFT
1087 EED210         INC ATAB+4          ;SPRITE1 UP
108A EED310         INC ATAB+5          ;SPRITE1 RIGHT
108D CED610         DEC ATAB+8          ;SPRITE2 DOWN
1090 CED710         DEC ATAB+9          ;SPRITE2 LEFT
1093 CEDA10         DEC ATAB+$C         ;SPRITE3 DOWN
1096 EEDB10         INC ATAB+$D         ;SPRITE3 RIGHT
1099 2C10C0 JUMP    BIT KSTRB           ;CLEAR KEYBOARD
```

Listing 1 continued on page 72

```
LINE# LOC CODE   LINE

0104 109C 4C2210        JMP LOOP                 ;JUMP TO START
0105 109F        ;
0106 109F        ;
0107 109F        ;*********  STORE VIDEO REGISTERS  *************************
0108 109F        ;
0109 109F 8DC1C0 SREG   STA VREG                 ;STORE BYTE1
0110 10A2 8CC1C0        STY VREG                 ;STORE BYTE2
0111 10A5 60            RTS                      ;RETURN
0112 10A6        ;
0113 10A6        ;*************  LOAD KEYBOARD INPUT  **********************
0114 10A6        ;
0115 10A6 2C10C0 LOADN  BIT KSTRB                ;CLEAR KEYBOARD
0116 10A9 2C00C0 WAIT   BIT KBD                  ;TEST KEYBOARD
0117 10AC 10FB          BPL WAIT                 ;IS KEY PRESSED ?
0118 10AE AD00C0        LDA KBD
0119 10B1 29F0          AND #$F0                 ;TEST IF NUMERICAL INPUT
0120 10B3 C9C0          CMP #$C0
0121 10B5 F006          BEQ LETER
0122 10B7 AD00C0        LDA KBD
0123 10BA 290F          AND #$0F                 ;MASK OFF HIGH NIBBLE
0124 10BC 60            RTS                      ;RETURN
0125 10BD AD00C0 LETER  LDA KBD
0126 10C0 18            CLC
0127 10C1 6909          ADC #$09                 ;CONVERT INPUT TO HEX VALUE
0128 10C3 290F          AND #$0F                 ;MASK OFF HIGH NIBBLE
0129 10C5 60            RTS                      ;RETURN
0130 10C6        ;
0131 10C6        ;***********************  TABLES  ***
0132 10C6        ;
0133 10C6 02     ITAB   .BYT $02,$C2,$01,$80     ;INITIALIZE TABLE
0133 10C7 C2
0133 10C8 01
0133 10C9 80
0134 10CA 01            .BYT $01,$0E,$00,$01
0134 10CB 0E
0134 10CC 00
0134 10CD 01
0135 10CE        ;
0136 10CE 40     ATAB   .BYT $40,$60,$00,$03     ;SPRITE 0 ATTRIBUTE
0136 10CF 60
0136 10D0 00
0136 10D1 03
0137 10D2 60            .BYT $60,$60,$04,$07     ;SPRITE 1 ATTRIBUTE
0137 10D3 60
0137 10D4 04
0137 10D5 07
0138 10D6 40            .BYT $40,$80,$08,$0B     ;SPRITE 2 ATTRIBUTE
0138 10D7 80
0138 10D8 08
0138 10D9 0B
0139 10DA 60            .BYT $60,$80,$0C,$0F     ;SPRITE 3 ATTRIBUTE
0139 10DB 80
0139 10DC 0C
0139 10DD 0F
0140 10DE        ;
0141 10DE FF80   PTAB   .DBY $FF80,$8080,$8080,$8080    ;SPRITE 0 PATTERN
0141 10E0 8080
0141 10E2 8080
0141 10E4 8080
```

Listing 1 continued on page 76

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These six languages have been tailored especially for RCA CMOS microprocessors and Microboards.

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- ROM-able 1802 p-code interpreters, with and without floating point.
- Also available on CompuServe time-sharing service.

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- 1802 microprocessor dialect of PL-1.
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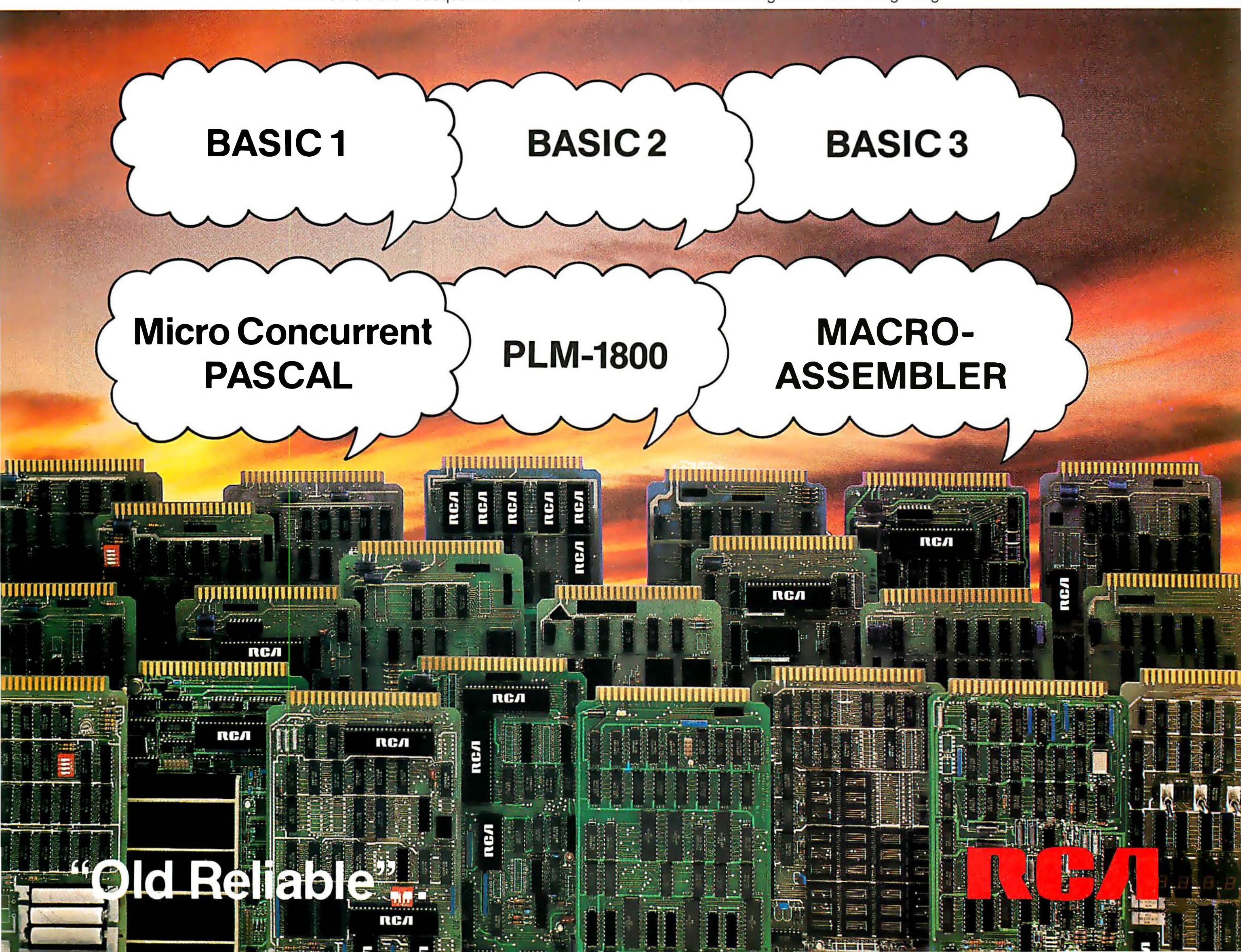
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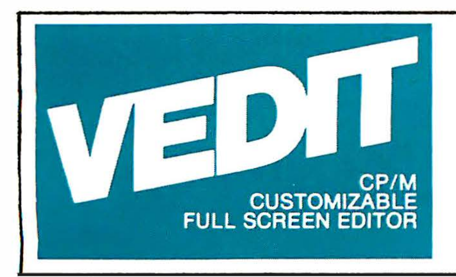
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Circle 355 on inquiry card.





The newest generation VEDIT combines sophisticated program development editing with useful word processing features and new powerful 'TECO' like macros.

User Oriented

Fast and easy editing for program development and word processing. Includes automatic screen scrolling, a status line with the cursor's line and column positions, an 'Undo' key, and recovery from full disk conditions (you can delete files or change disks). Fully adapts to your system with a menu driven customization for keyboard layout, CRT selection and more. Since VEDIT receives major enhancements twice a year, you're assured that VEDIT will always be 'state of the art' with our inexpensive update option and support you can really count on.

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Exceptional speed and true 'what you see is what you get' full screen editing with a convenient array of cursor movements and editing functions. Edits files up to one disk in length, and holds up to 45K of a file entirely in memory. You can insert a specified line range of another file anywhere in the text, and change disks in the middle of an edit session. Includes search and replace, text move and copy, complete file handling and flexible macros. Unique automatic indenting for use with structured languages such as Pascal, 'C' and PL/I. Other features for assembly language, Fortran and Cobol.

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Features include word wrap, adjustable left margin, reformatting of paragraphs, word and paragraph oriented cursor movement and deleting, and printing with imbedding of printer control characters. May be used stand-alone or in conjunction with most text output processors.

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CRT version supports over 40 terminals, including ANSI standard and all screen sizes. Utilizes 'smart' terminal features for fast screen updating. Your keyboard layout can use any available function and cursor keys. Memory mapped version offer high speed, flexibility, supports bank select and the SSM VB3. Versions for Fulcrum VIO-X, PIICEON and TDL video boards.

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Ten buffers can hold macro command strings. These may be executed, edited, saved and loaded from disk. Macros can perform complex editing operations. (For example, a macro could automatically perform a series of global search and replace on many files). The buffers may also hold text, allowing extensive text 'cut and paste', including portions from multiple files. New startup command file can also setup VEDIT parameters, initialize a terminal's programmable function keys and more.

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Please specify your microcomputer, video board or the CRT terminal version, 8080, Z80 or 8086 code, and disk format.

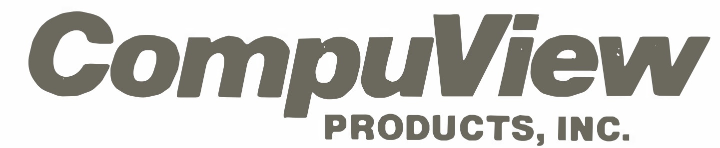
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Circle 110 on inquiry card.

Listing 1 continued:

```
LINE# LOC  CODE   LINE

0142 10E6 8080          .DBY $8080,$8080,$8080,$80FF    ;16 X 16 PIXELS
0142 10E8 8080
0142 10EA 8080
0142 10EC 80FF
0143 10EE FF01          .DBY $FF01,$0101,$0101,$0101    ;32 BYTES / SPRITE
0143 10F0 0101
0143 10F2 0101
0143 10F4 0101
0144 10F6 0101          .DBY $0101,$0101,$0101,$01FF
0144 10F8 0101
0144 10FA 0101
0144 10FC 01FF
0145 10FE          ;
0146 10FE FF80          .DBY $FF80,$879F,$9880,$8083    ;SPRITE 1 PATTERN
0146 1100 879F
0146 1102 9880
0146 1104 8083
0147 1106 8380          .DBY $8380,$8098,$9F8F,$80FF
0147 1108 8098
0147 110A 9F8F
0147 110C 80FF
0148 110E FF01          .DBY $FF01,$F1F9,$1919,$31F1
0148 1110 F1F9
0148 1112 1919
0148 1114 31F1
0149 1116 F139          .DBY $F139,$1919,$F9F1,$01FF
0149 1118 1919
0149 111A F9F1
0149 111C 01FF
0150 111E          ;
0151 111E AA55          .DBY $AA55,$AA55,$AA55,$AA55    ;SPRITE 2 PATTERN
0151 1120 AA55
0151 1122 AA55
0151 1124 AA55
0152 1126 AA55          .DBY $AA55,$AA55,$AA55,$AA55
0152 1128 AA55
0152 112A AA55
0152 112C AA55
0153 112E AA55          .DBY $AA55,$AA55,$AA55,$AA55
0153 1130 AA55
0153 1132 AA55
0153 1134 AA55
0154 1136 AA55          .DBY $AA55,$AA55,$AA55,$AA55
0154 1138 AA55
0154 113A AA55
0154 113C AA55
0155 113E          ;
0156 113E AAAA          .DBY $AAAA,$AAAA,$AAAA,$AAAA    ;SPRITE 3 PATTERN
0156 1140 AAAA
0156 1142 AAAA
0156 1144 AAAA
0157 1146 AAAA          .DBY $AAAA,$AAAA,$AAAA,$AAAA
0157 1148 AAAA
0157 114A AAAA
0157 114C AAAA
0158 114E AAAA          .DBY $AAAA,$AAAA,$AAAA,$AAAA
0158 1150 AAAA
0158 1152 AAAA
0158 1154 AAAA
```

Listing 1 continued on page 78

galaxy of features

A GALAXY of features makes the **LNW80** a remarkable computer. As you explore the **LNW80,** you will find the most complete, powerful, ready to run, feature-packed personal and business computer ever made into one compact solid unit.



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LNW Research Corp.
2620 WALNUT Tustin, CA. 92680
(714) 641-8850 (714) 544-5744

Monitor and Disk drives not included
TM Personal Software, Inc.

Circle 232 on Inquiry card.

Listing 1 continued:

```
LINE# LOC CODE    LINE

0159 1156 AAAA            .DBY $AAAA,$AAAA,$AAAA,$AAAA
0159 1158 AAAA
0159 115A AAAA
0159 115C AAAA
0160 115E         ;
0161 115E                 .END


ERRORS = 0000 <0000>



SYMBOL TABLE

SYMBOL    VALUE

ATAB    10CE  CBACK   104C  CSIZE   105B
FILL    1019  INIT1   1004  ITAB    10C6
JUMP    1099  KBD     C000  KSTRB   C010
LETER   10BD  LOADN   10A6  LOOP    1022
MOVE    107A  NEXA    102B  NEXF    1017
NEXTS   1040  ONE     106C  PTAB    10DE
SLOT    0040  SREG    109F  VDATA   C0C0
VREG    C0C1  WAIT    10A9
END OF ASSEMBLY
```

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...WITH A FULL HOUSE OF 5¼" DRIVES

Micro-Sci has three disk drives and two controllers so you can configure your Apple II™ or Apple II Plus™ system to fit your individual budget and performance requirements.

THE FIRST ACE—A2

The new A2 is the price/compatibility substitute for the Disk II,™ intended as the second drive on an existing controller, or as a full A2 subsystem. The A2 drive or A2 subsystem is an ideal choice when the drives will be primarily used for entertainment or prepackaged software programs.

THE SECOND ACE—A40

The A40 is a price/performance alternative to the Disk II. With 40 tracks, you get an additional 20K bytes, and faster track-to-track access. The A40 is intended for use in dedicated DOS, CP/M and Pascal applications, and as a companion drive for the A70. The A40 is Micro-Sci's most cost-effective disk subsystem for the Apple IIs.

THE THIRD ACE—A70

The A70 is the price/capacity alternative. At over a quarter million bytes per drive, the A70 has the capacity of two Disk IIs or an eight-inch floppy, but costs only slightly more than a single Disk II. One A70 supports a DOS file as large as 270K, a CP/M file up to 254K, and 560 blocks in Pascal.

THE PAIR—MICRO-SCI'S CONTROLLERS

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inued from page 67:

```
TELL 0
SETSHAPE :BOX
SETCOLOR :GREEN
SXY 20 20
```

The first command specifies that sprite 0 is being addressed. The second tells Logo to use the predefined box pattern, while the third says that the sprite is to be colored green (remember, the rest of the sprite plane will be transparent). Then the fourth command states that the sprite is to be drawn at coordinate 20,20.

Now, to add the blue box as sprite 1 at x,y coordinates 12,12.

```
TELL 1
SETSHAPE :BOX
SETCOLOR :BLUE
SXY 12 12
```

Finally, to draw the red box as sprite 2 at position 5,5.

```
TELL 2
SETSHAPE :BOX
SETCOLOR :RED
SXY 5 5
```

A turtle can be drawn simply by using a similar procedure substituting the command SETSHAPE :TURTLE.

At this writing, Terrapin MIT Logo does not support turtle velocity (automatic constant movement actuated by the commands SETSPEED and SETHEADING) as does the Logo package available for the Texas Instruments TI 99/4A microcomputer, but a future version of Terrapin's product may do so.

In Conclusion

The TMS9918A Video Display Processor has many more capabilities than I have room to write about here, and my examples of a few boxes and turtles are an inadequate demonstration of the powerful combination of the E-Z Color Graphics Interface and Terrapin MIT Logo. I am certain that you can fully appreciate them only by observing a dynamic display and seeing how few commands are needed to create it.

I don't usually get excited over mega-bit-width processors or super-high-level languages. What does excite me, however, is taking one of my projects hot off the soldering iron and seeing it operate so easily in synergism with someone else's work. After seeing the graceful mating of the E-Z Color Graphics Interface with Terrapin MIT Logo, I can't help but be excited about other sprite-graphics applications.

Next Month:

Build the MicroVox text-to-speech voice synthesizer. ■

References

1. Guttag, Karl and John Hayn. "Video Display Processor Simulates Three Dimensions," *Electronics*, November 20, 1980, page 123.
2. Nelson, Harold. "Logo for Personal Computers," BYTE, June 1981, page 36.
3. *TMS9918A Video Display Processor*. Houston, TX: Texas Instruments Semiconductor Group, 1981.

Editor's Note: *Steve often refers to previous Circuit Cellar articles as reference material for each month's current article. Most of these past articles are available in reprint books from BYTE Books, 70 Main St., Peterborough, NH 03458.* Ciarcia's Circuit Cellar, Volume I, *covers articles that appeared in BYTE from September 1977 through November 1978.* Ciarcia's Circuit Cellar, Volume II, *contains articles from December 1978 through June 1980.* Ciarcia's Circuit Cellar, Volume III, *contains the articles that were published from July 1980 through December 1981.*

To receive a complete list of Ciarcia's Circuit Cellar project kits available from the Micromint, circle 100 on the reader service inquiry card at the back of the magazine.

Parts Source

The following products are available from:

The Micromint Inc.
917 Midway
Woodmere, NY 11598
telephone: (516) 374-6793
(for technical data)
(800) 645-3479
(orders only)

Apple II plug-compatible E-Z Color Graphics Interface, provided with user manual, sample programs, and TMS9918A reference manual.

Assembled and tested $175
Kit $150

Terrapin MIT Logo for the Apple II; requires 48K-byte user memory and one floppy-disk drive.

On DOS version 3.3 disk . . Call for price

S-100-bus and IBM Personal Computer versions of the E-Z Color Graphics Interface are planned. Call for price and availability.

Prices include shipping in the U.S. Foreign orders add $8 for shipping. Residents of the state of New York please add 7% sales tax.

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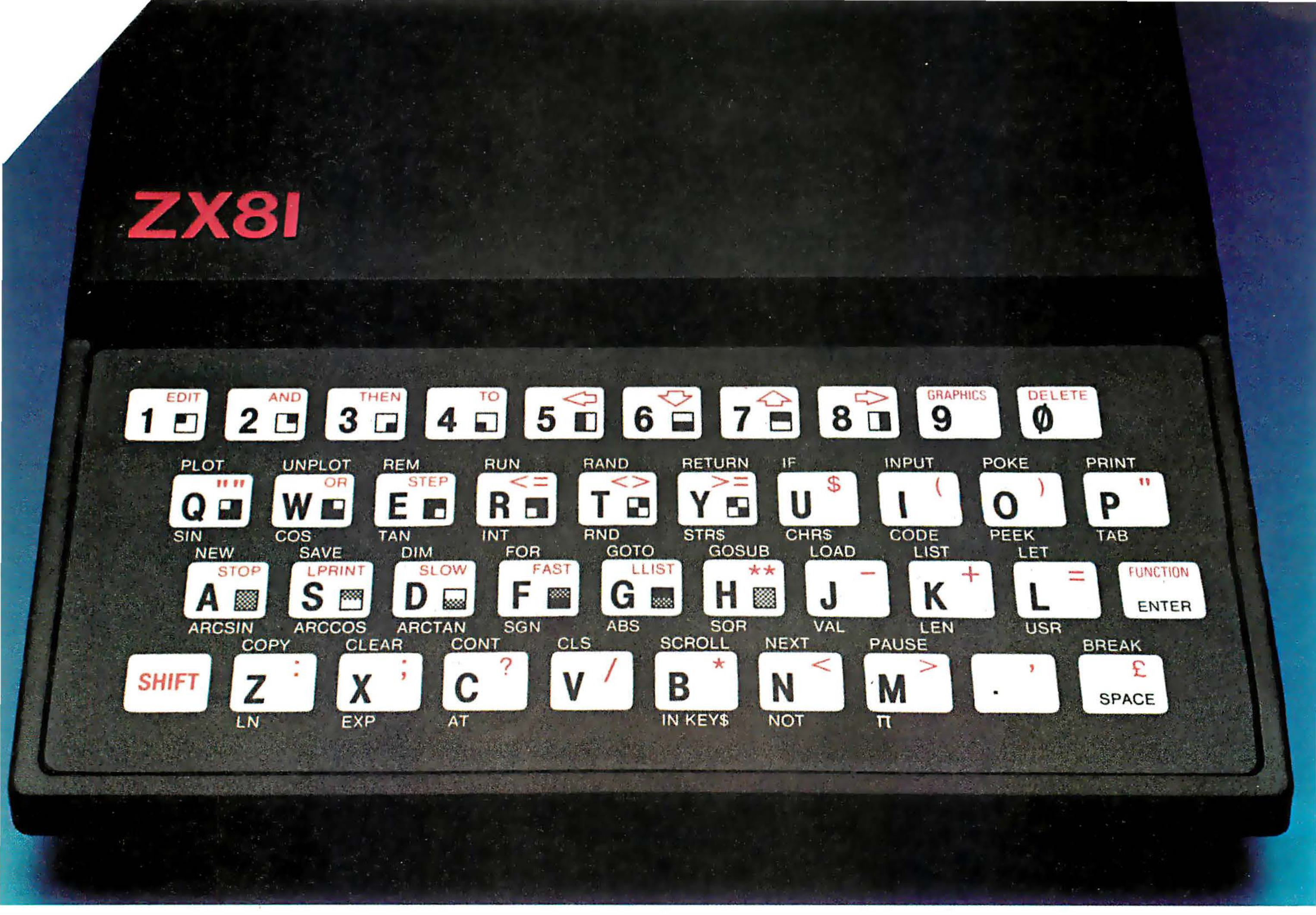
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The ZX81 is a major advance over the original Sinclair ZX80—the first personal computer to break the price barrier at $200.

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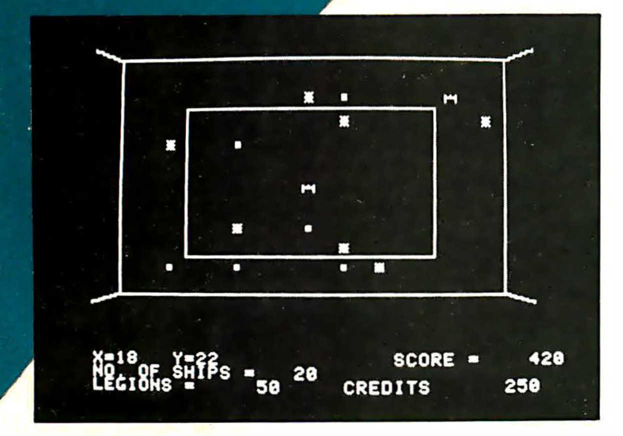
- Continuous display, including moving graphics
- Multi-dimensional string and numerical arrays
- Mathematical and scientific functions accurate to 8 decimal places
- Unique one-touch entry of key words like PRINT, RUN and LIST
- Automatic syntax error detection and easy editing
- Randomize function useful for both games and serious applications
- 1K of memory expandable to 16K
- A comprehensive programming guide and operating manual

The ZX81 is also very convenient to use. It hooks up to any television set to produce a clear 32-column by 24-line display. It comes with a comprehensive programming guide and operating manual designed for both beginners and experienced computer users. And you can use a regular cassette recorder to store and recall programs by name.

Sinclair technology is also available in Timex/Sinclair computers under a license from Sinclair Research Ltd.

And The Winners Are...

For those of you breathlessly awaiting the results of BYTE's Game Contest (see the December 1981 BYTE for details), direct your attention to the display before you. Although it was difficult to convince the judges to abandon their everyday routine and spend hours playing games, everyone eventually made that ultimate sacrifice. With bloodshot eyes fixed on the displays and nervous fingers manipulating keyboards and joysticks, these tireless individuals toiled day and night. And when the chairs were finally pushed away from the table . . .

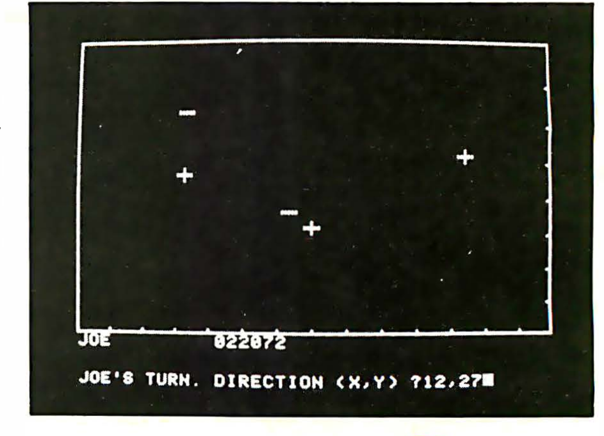


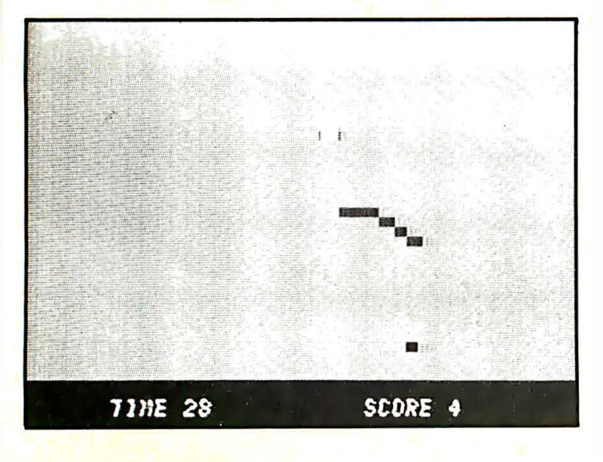
1

Cosmic Conquest Apple II
Alan Sartori-Angus
Grahamstown, Republic of South Africa
A real-time space strategy game.

2

Apple II **CHARGE!**
C. Anthony Ray
Urbana, Illinois
A trajectory game that shoots electrons through stationary ions.



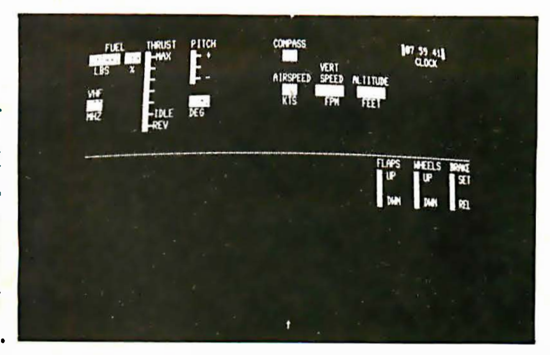


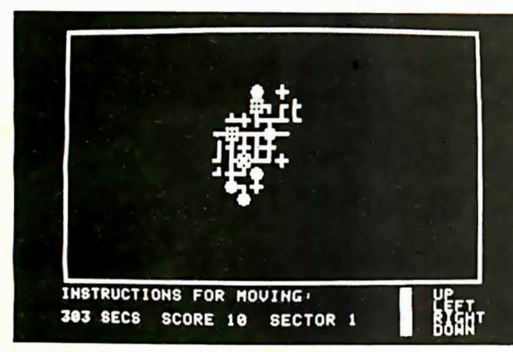
3

The Game of Rat and Dragon Apple II
Truck Smith
Fullerton, California
A chase with a rat, some cheese, and a dragon.



TRS-80 Model III **JETSET (Jet Simulator Electronic Trainer)**
Gene Szymanski
Princeton, New Jersey
A flight simulator.



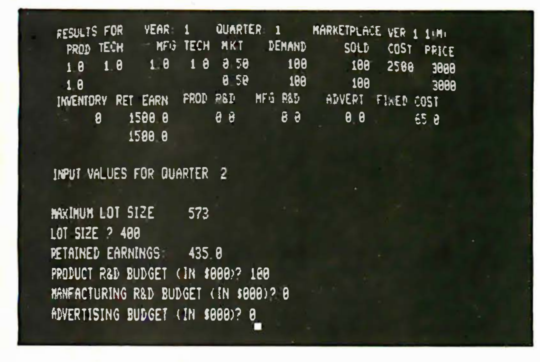


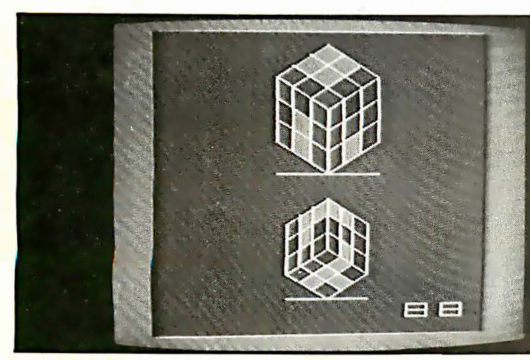


RINGQUEST Apple II
Gordon Mills
Bradford, England
A Tolkien-style adventure.



TRS-80 Model III **MARKETPLACE**
Robert Dickinson
Thousand Oaks, California
A two-machine marketing simulation.



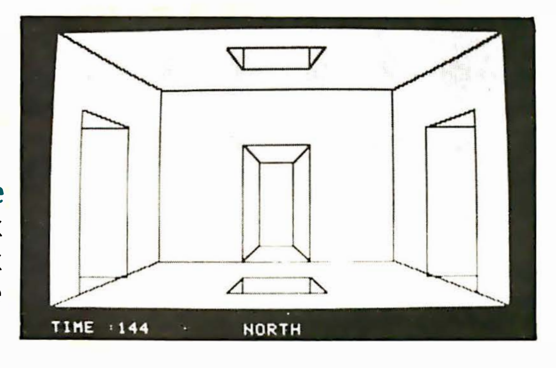




Three Dee Tee TRS-80 Color Computer
John Stuart
Tulsa, Oklahoma
Tic-tac-toe on a Cube.



Apple II **Quinti-Maze**
Robert Tsuk
Plattsburgh, New York
A five by five by five cubic maze.



Think you have a better idea? . . . then read on

A Few Details

A detailed description and complete listing of each of the winning games will be published in future issues of BYTE. Beginning in September, two entries will be featured each month, culminating with the first and second place winners in the December 1982 BYTE games issue. Overall, the games submitted were original, playable, and enjoyable.

Fifty-one entries were received from 21 states and 6 foreign countries. Other statistics about the entries include:

Machines Used

- 19 Apples
- 13 TRS-80 Models I/III
- 9 TRS-80 Color Computers
- 4 Commodore VICs
- 3 CP/M machines
- 2 TRS-80 Model IIs
- 1 Atari 400/800

Types of Games Received

- 26 arcade games
- 8 simulations
- 7 adventures
- 5 board games
- 5 puzzle games

Programming Languages Employed

- 40 BASIC games
- 5 BASIC/machine-language games
- 3 machine-language games
- 2 Pascal games
- 1 FORTH game

Special thanks goes to Jon Swanson who administered the Game Contest and kept everything under control.

BYTE Game Contest #2



* PRIZES *

Some Fortune, Some Fame
First Prize: $500 Second Prize: $300
Third, Fourth, and Fifth Prizes: a custom-embroidered BYTE jacket. Several Honorable Mention certificates will also be awarded for other noteworthy games. All winning games (including Honorable Mention games) will be published in BYTE.

* A Game Is A Game Is A Game Is A Game Is A... *

What kinds of games are we looking for? Anything that's fun! Graphic arcade-style games, strategy games, puzzle games, text-only adventures, single- or multiplayer simulations, abstract games, and historical games. A game doesn't need to occupy 48K bytes of memory to be fun—it's the concept that counts! (For example, see Quinti-Maze and Three Dee Tee, the games to be published in the September 1982 BYTE.) We aren't interested in computer versions of games that already exist—we want to see something original!

* All The Rules Fit To Print *

- This contest will be judged by the BYTE editorial staff. Factors influencing the decision will be the originality and playability of the game, as well as the quality of the accompanying manuscript. The judges' decision is final.
- All entries should be marked on the outside: "MAGNETIC MATERIALS—DO NOT X-RAY."
- Game submissions cannot be returned unless they are accompanied by a return envelope stamped with sufficient postage.
- This contest is open to anyone except employees or immediate family of McGraw-Hill and its subsidiaries. Void where prohibited by law.
- Prizewinners will give all rights to the article to BYTE in exchange for the designated prizes. In all cases, the author retains all commercial rights to the software written, and *BYTE readers may not distribute and/or sell the software without the author's permission*. All prizewinners will receive the standard payment for a BYTE article ($50 per published magazine page).
- Only one entry per contestant is permitted.
- Games *must* be in the format specified.

* Computers and Formats *

Prepare your game for one of the following computers, in the format indicated. (We apologize if your computer is not on this list, but we are limited by those to which we have access.) Games *must* be submitted on the appropriate media.

Apple II, Atari 800, Commodore PET/CBM, IBM Personal Computer, Radio Shack TRS-80 Model I or III: 5¼-inch disk

Commodore VIC, Radio Shack TRS-80 Color Computer: cassette tape

Radio Shack TRS-80 Model II: 8-inch disk

CP/M with "plain vanilla" terminal (i.e., no special features of the terminal are used): single-density 8-inch disk

Note: All disks (except for CP/M systems) must contain the operating system used and two copies of the game you are submitting. If your game is on cassette tape, be sure to record several copies of the game on a high-quality tape recorder.

Submit your game on the magnetic media listed for your computer. Include whatever documentation may be necessary to play your game: a clear listing on unlined paper, a brief introduction to the game, how it was designed, and how it works. All written materials should be typed double-space for possible publication in BYTE. (Send a stamped, self-addressed legal-size envelope for a copy of our author's guide.)

* DEADLINE *

Entries must be sent to:

BYTE Game Contest
POB 372
Hancock, NH 03449

Entries will *not* be accepted before January 1, 1983, and must be postmarked no later than February 15, 1983. Results will be published in the July 1983 BYTE.

* Hints, Clues, Tricks, and Other Helpful Info *

Four words are your passport to success in the Second BYTE Game Contest:
Imagination, Playability, Presentation, and Simplicity

Imagination: What the gaming community has seen very rarely is a game that fully exploits the unique strengths of the computer (and avoids its weaknesses). Ask yourself, "What is my computer good at? How can I design a game around it? What kind of game can I create that has never been seen before?"
Playability: A technically perfect game that isn't fun to play has no chance in the Second BYTE Game Contest. Be sure that your game appeals to the player(s): action games should have variation, pacing, and increasing levels of difficulty; strategy games should give the players a "rich" set of moves that allow them to exercise their ingenuity and cunning in the face of victory or defeat; adventures should be self-consistent and clever. All games should make user input easy to understand by including error-trapping and other user-friendly features.
Presentation: You should pay as much attention to your presentation as you do to your game. In the next four months, look over BYTE's publication of winning entries (from the First Game Contest) to see which presentations caught our eye!
Simplicity: This quality is such an important component of playability that it deserves special mention. Games, like short stories or vintage automobiles, require polishing to look their best—and much of that polishing is cutting out extraneous or confusing details and refining the game design to a sleek final version. Remember the adage, "Less is more."

A Beginner's Guide to Logo

Logo is not just for kids.

Harold Abelson
Laboratory for Computer Science
MIT NE43-805
Cambridge, MA 02139

In the 1960s, computers were very expensive and didn't have much memory. A computer such as the IBM 1620 could store a maximum of 24K bytes (or 60,000 decimal digits). Even the largest research computers could manage only six times that much. Since programs had to use memory sparingly, computer languages were designed to reflect this concern.

Languages had to be simple for the computer, even at the expense of being cumbersome for the programmer. For example, to help the compiler keep track of memory, most programming languages insisted on a close tie between the *names* used in a program and the *storage cells* in the computer memory. As a consequence, the only kinds of data objects that could be directly named and manipulated by program operations were those that could be stored in a single cell. The only data structures available were those whose size could be prespecified at compile time. Most languages also required the programmer to include bookkeeping "declaration" statements, or adhere to other restrictions on the use of names, to make it easy for the compiler to determine what kind of storage each variable required. (For example, some languages required names beginning with I or J to refer to integers, arrays had to be declared together with their size, and defined functions had to have a name beginning with FN, followed by a digit.)

The concern for conserving memory permeated not only the language, but the computer system as a whole. For instance, if the system included a program editor, editing a line of code required the programmer to abort the program, load the editor, read a file, perform the edit, write a new file, exit the editor, recompile the edited code, and reload the program. All this because the editor and the language could not fit into main memory at the same time.

The languages of the 1960s flourished with the personal computers of the 1970s, which, although no longer very expensive, still did not have much memory. As personal computers became more popular, people began to confuse the idea that a language that is simple *for a computer* would also be simple *for people*. ("BASIC has only a few primitives; therefore, it must be easy to learn.") Some people even rationalized that the cumbersome features of such languages were actually advantages. ("Having to declare the data types of variables makes you organize your programs better." "If it's too easy to edit programs, you won't write them carefully in the first place.") And when educators explored the potential uses of computers, they often accepted the drawbacks of these languages as an integral part of programming.

Over the past 12 years, the Logo Group at MIT under the direction of Seymour Papert, along with colleagues at a few universities and research centers around the world, has taken a different approach to educational computing. Rather than accept the limitations of affordable computers (by the standards of those days), we worked with the largest research computers available. The system we used, called Logo, is essentially a dialect of LISP, a powerful language developed for research in artificial intelligence, and used a great deal of memory compared to standards of the 1960s. (Some of the important linguistic aspects of Logo are discussed in "Why Logo?" by Brian Harvey in this issue on page 163. For a more general perspective on LISP, see "An Overview of Lisp" by John Allen in the August 1979 BYTE, page 10.)

In working with Logo, we've discovered some important things. A computer language can be both sim-

About the Author

Harold Abelson, a professor of Computer Science and Education at the Massachusetts Institute of Technology, is also the author of Logo for the Apple II *and* Apple Logo, *introductions to the Logo programming language, published by BYTE/McGraw-Hill Books.*

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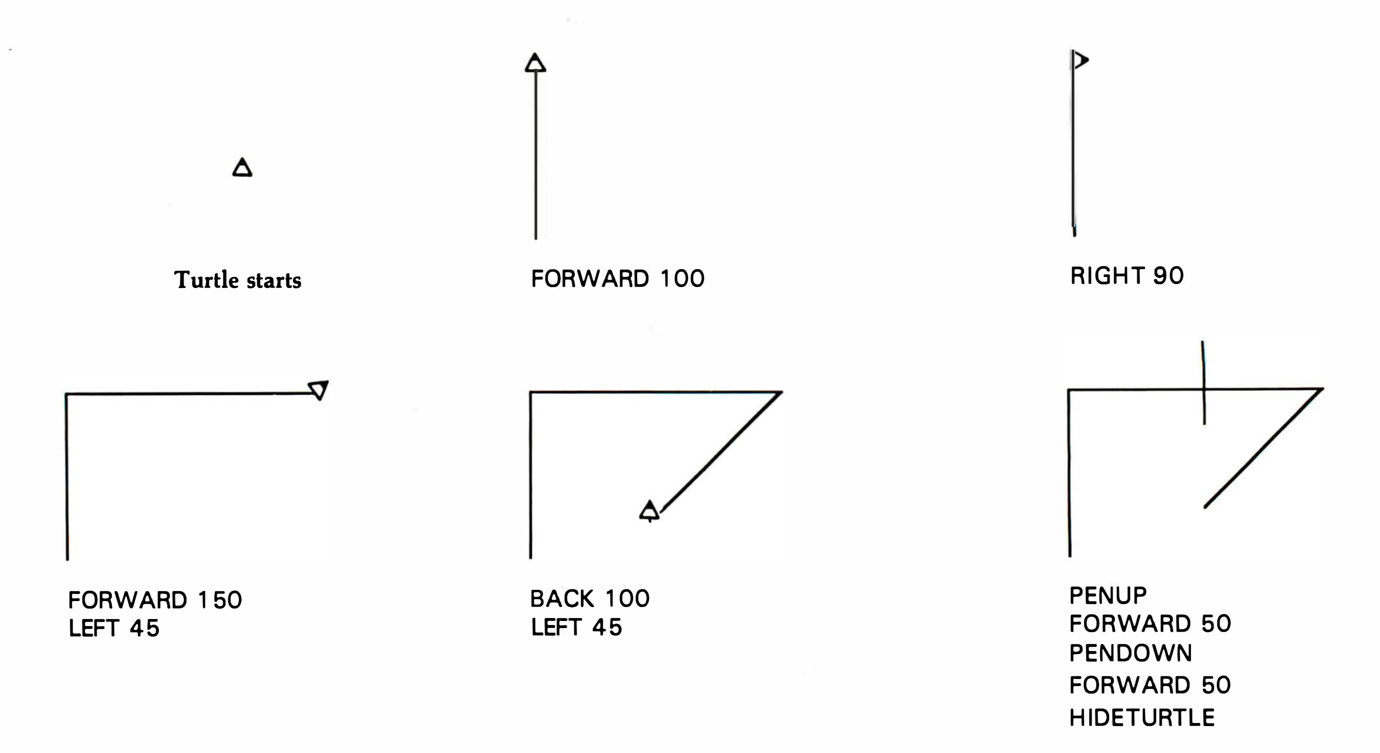


Figure 1: *Moving the turtle with a simple sequence of Logo commands.* FORWARD *moves the turtle in the direction it is facing.* RIGHT *and* LEFT *rotate the turtle.* PENUP *and* PENDOWN *raise and lower the pen—the turtle leaves a trace when it moves with the pen down.*

ple and powerful at the same time. In fact, these two aspects are complementary rather than conflicting because it is the very lack of expressive power in primitive languages such as BASIC that makes it difficult for beginners to write simple programs that do interesting things. More important, we've found that it is possible to give people control over powerful computational resources, which they can use as tools in learning, playing, and exploring. This has often required us to go beyond ordinary considerations of computer-language design to create compelling images of how computation can provide a perspective for reformulating traditional ideas from science and mathematics to make them more accessible, more in tune with intuitive modes of thought. In our research at MIT, working with preschool, elementary, junior high, high school, college students, and with their teachers, we've used Logo to introduce programming and the computational perspective at all levels. In this article, I'd like to show you what it's like to program using Logo, a simple but powerful system, enabling you to explore with a computer.

Drawing with the Turtle

Let's begin with a look at some *turtle graphics.* The turtle is a small triangular pointer on the screen that responds to a few simple commands. FORWARD moves the turtle in the direction it is facing a given number of units. If you type the Logo command FORWARD 50, the turtle will respond by moving forward 50 turtle steps (about 1/4 the height of the screen). RIGHT rotates the turtle clockwise a given number of degrees. BACK and LEFT cause the movements opposite to FORWARD and RIGHT. The turtle also carries a pen, which leaves a trace of its path on the screen as it moves while the pen is down. The commands PENUP and PENDOWN make the turtle raise and lower the pen. Figure 1 shows the result of a simple sequence of Logo commands.

It's lots of fun to make drawings by using these commands (together with a few others, such as CLEARSCREEN, which erases the screen). But in order to really make progress, you have to teach the computer some new words. For instance, you can teach the computer that the turtle can draw a square by repeating this sequence four times: go FORWARD 50 steps, turn RIGHT 90 degrees. The Logo commands would be:

```
TO SQUARE
REPEAT 4 [FORWARD 50 RIGHT 90]
END
```

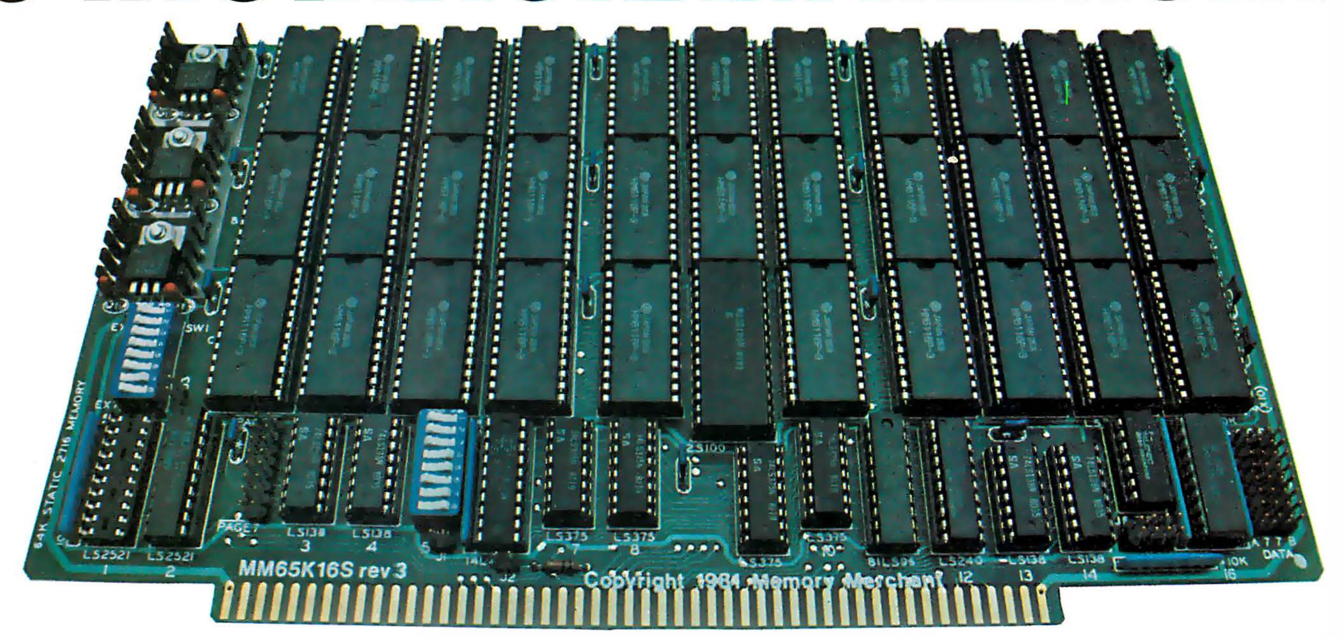
SQUARE is an example of a Logo *procedure.* The first line (signaled by TO) specifies the name of the procedure. This procedure happens to be called SQUARE (since that's what it draws), but you could have called it anything. The rest of the procedure (the procedure's *body*) specifies the list of instructions to be carried out in response to the command SQUARE; the word END indicates the end of the definition.

Once defined in this way, SQUARE becomes part of the computer's vocabulary. Whenever you give the command SQUARE, the turtle will draw a square.

Procedures with Inputs

An important difference exists between SQUARE and FORWARD. SQUARE always draws a square 50 steps on a side. But FORWARD is more versatile; it takes an *input* that determines how far the turtle should

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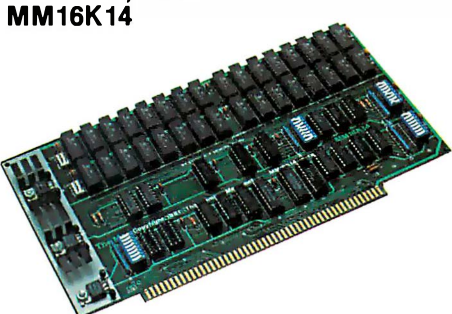
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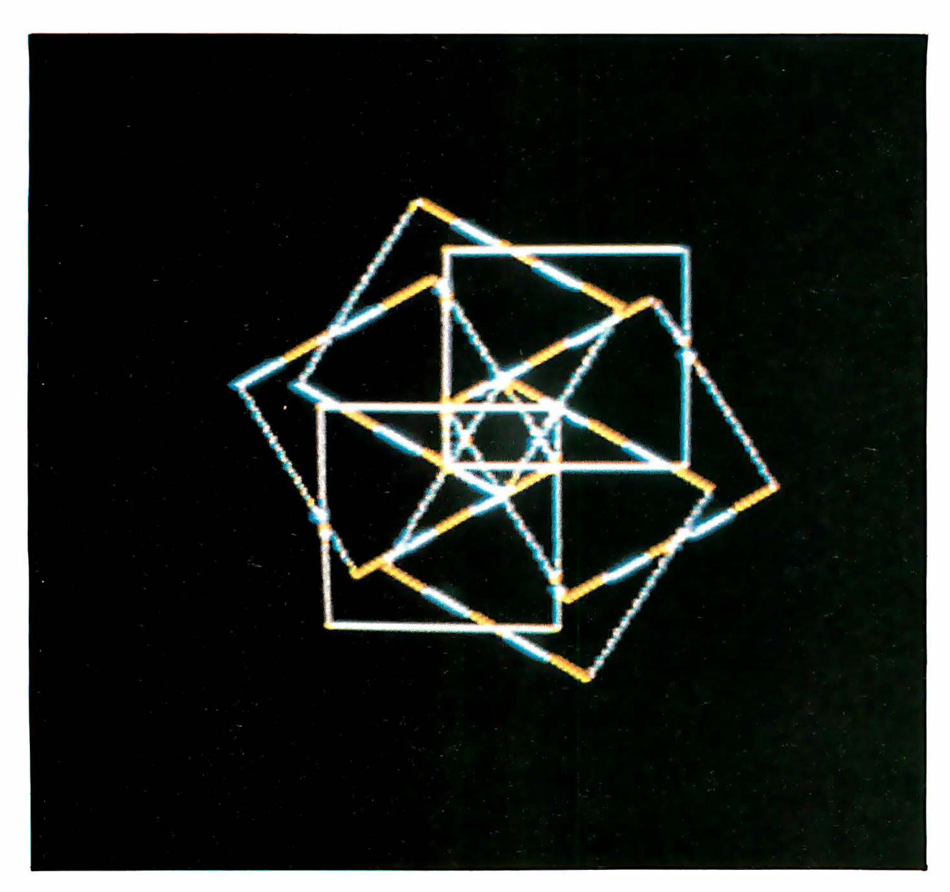


Photo 1: *A design created by a simple one-line Logo program that makes the turtle repeat these steps six times: go* FORWARD 20 *units, turn* RIGHT 60 *degrees, and draw a square of size 75 units.*

move. You can change the SQUARE procedure so that it also takes an input that determines the size of the square to be drawn. For example:

```
TO SQUARE :SIZE
REPEAT 4 [FORWARD :SIZE RIGHT 90]
END
```

You use SQUARE just as you would any Logo command that takes an input. That is, to draw a square with 100-step sides, you type:

```
SQUARE 100
```

To draw a square with 50-step sides, you type:

```
SQUARE 50
```

The definition of SQUARE illustrates the general rule for defining procedures that take inputs. You choose a name for the input and include it in the procedure title line preceded by a colon. Then you use the input name (with the colon) in the procedure body wherever you would normally use the value of the input.

Since a procedure, once defined, becomes just another word the computer "knows," you can use procedures as parts of the definitions of other procedures. Here's a procedure that produces a design by repeatedly going forward, turning, and drawing a square (see photo 1):

```
TO DESIGN
REPEAT 6 [FORWARD 20
  RIGHT 60 SQUARE 75]
END
```

Simple Recursive Procedures

This next procedure also draws a square of a specified size:

```
TO SQ :SIZE
FORWARD :SIZE
RIGHT 90
SQ :SIZE
END
```

Although SQ and SQUARE both draw squares, they behave very differently. Instead of drawing a square and then stopping, SQ makes the turtle retrace the same path over and over, or until you tell the computer to stop. Here is why this happens. When you give the command:

```
SQ 100
```

the turtle must go FORWARD 100, RIGHT 90, and then do SQ 100 again, and so on, and so on.

Add a second input to SQ and you obtain a procedure called POLY, which repeats over and over the sequence: go FORWARD some fixed distance, and turn RIGHT some fixed angle. The procedure takes as inputs the size of each FORWARD step and the amount of each turn:

```
TO POLY :SIZE :ANGLE
FORWARD :SIZE
RIGHT :ANGLE
POLY :SIZE :ANGLE
END
```

To use the POLY procedure, type the word POLY, followed by specific values for the inputs:

```
POLY 60 144
```

Figure 2 shows some of the many different shapes obtained by calling POLY with various inputs.

Recursion is the programming word to describe the ability to use a procedure as part of its own definition. SQ and POLY are recursive procedures of a very simple form—they merely repeat an unchangeable cycle over and over. But recursion is a much more powerful idea and can be used to obtain much more complicated effects. To take just a small step beyond the purely repetitive kind of recursion, consider:

```
TO POLYSPI :SIZE :ANGLE
FORWARD :SIZE
RIGHT :ANGLE
POLYSPI :SIZE+3 :ANGLE
END
```

Giving the command

```
POLYSPI 1 120
```

leads to this sequence of turtle moves:

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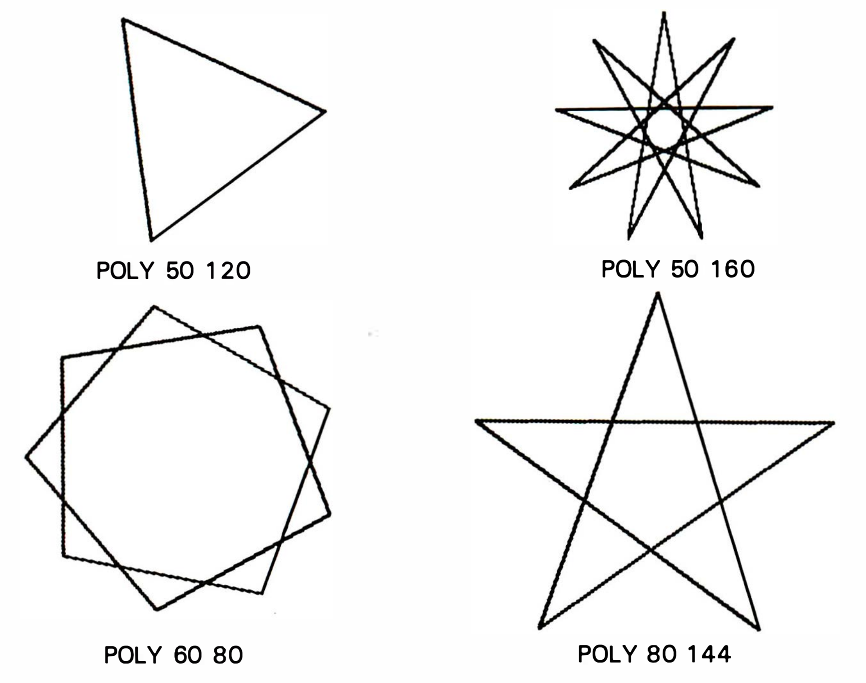


Figure 2: *These shapes are all drawn by the three-line Logo program* POLY, *which has the turtle go* FORWARD *some fixed amount, turn* RIGHT *some fixed angle, and repeat this over and over. The figures drawn by* POLY *always close, but the number of sides that must be drawn before the figure closes depends upon the* ANGLE *input to the procedure.*

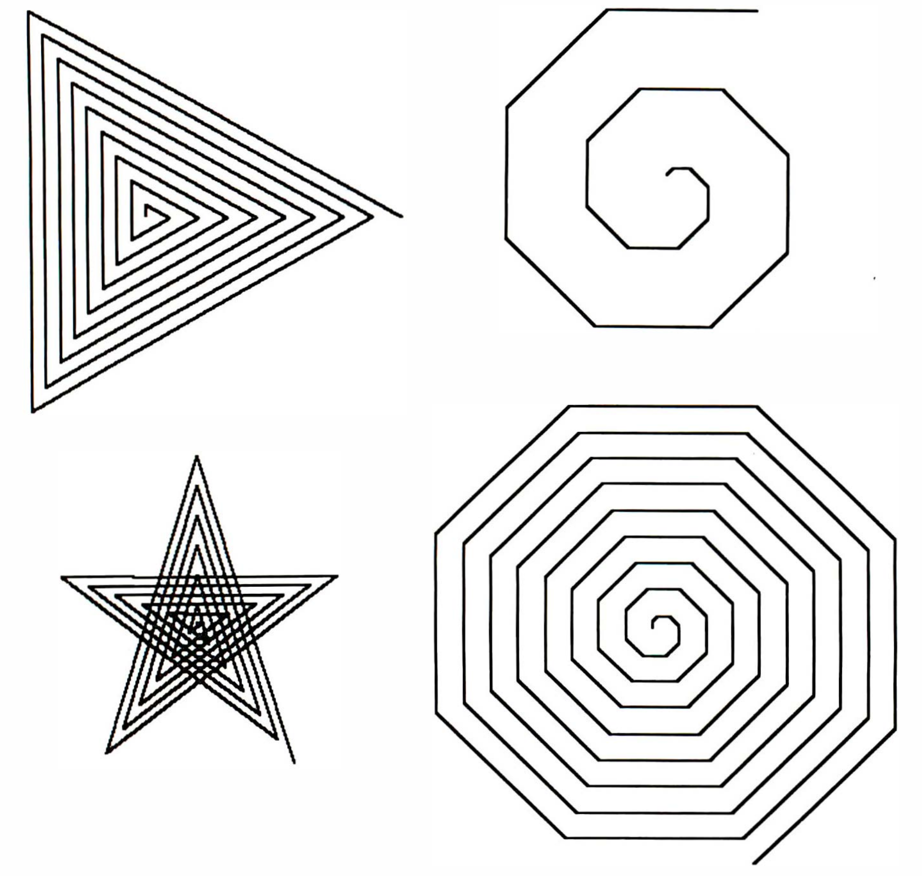


Figure 3: *Figures created using* POLYSPI. *A variant of* POLY *(see figure 2), the program takes advantage of recursion to increase the turtle's* FORWARD *step each time the procedure calls itself. The result is a polygonal spiral. As with* POLY, *varying the* ANGLE *input changes the symmetry of the pattern.*

```
FORWARD 1
RIGHT 120
FORWARD 4
RIGHT 120
FORWARD 7
RIGHT 120
FORWARD 10
RIGHT 120
.
.
.
```

which produces a triangular spiral in which each of the sides is three steps larger than the previous side. Figure 3 shows some of the shapes generated by the POLYSPI procedure. As a variant, you can replace the FORWARD step in POLYSPI by a command that draws a square:

```
TO SPINSQUARE :SIZE :ANGLE
SQUARE :SIZE
RIGHT :ANGLE
SPINSQUARE :SIZE+3 :ANGLE
END
```

The result of running

```
SPINSQUARE 1 10
```

as shown in figure 4 is a sequence of squares of increasing size starting with a square of one-step size. Each square is three units larger than the previous one and rotated from it by 10 degrees. The procedure keeps running and the squares keep growing until you tell Logo to stop. You can also modify the procedure so that it stops when the squares become larger than a certain size (e.g., 100 steps) by including a *stop rule*:

```
TO SPINSQUARE :SIZE :ANGLE
IF :SIZE > 100 THEN STOP
SQUARE :SIZE
RIGHT :ANGLE
SPINSQUARE :SIZE+3 :ANGLE
END
```

Part of the power of recursion is the fact that such simple programs can lead to such varied results.

An Environment for Exploring

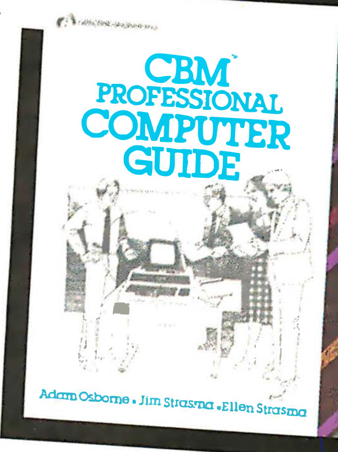
As you can see from the examples presented so far, it is very easy to get started programming with turtle graphics. This is partly because of the *subject matter* of turtle graphics. The basic commands have simple, visible effects. At the same time, turtle graphics is an incredibly rich area for

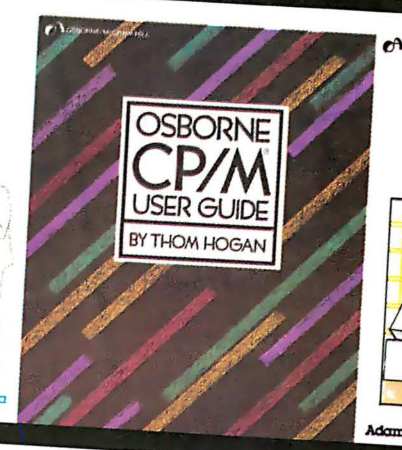
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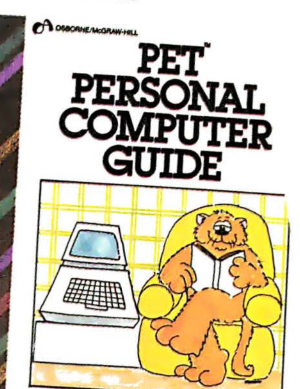
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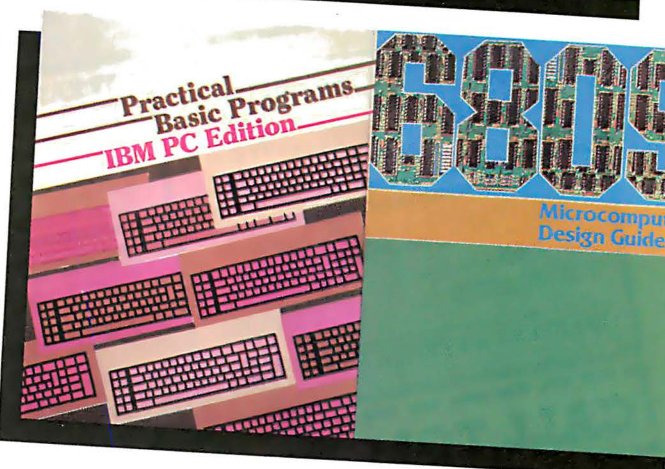








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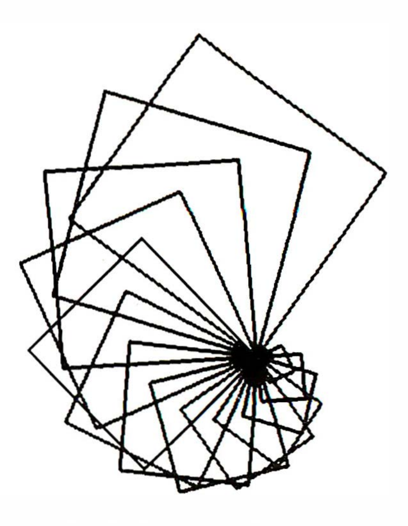


Figure 4: SPINSQUARE *is a simple recursive program that draws a square of a given size, rotates it, increases the size, and continues the process.*

exploration in which even simple programs can have unexpected, often beautiful results. The small amount of Logo we've seen so far is enough to support weeks of activities in programming and mathematics, exploring such questions as "How does the shape of a POLY figure depend on the angle input?" or "Why do so many repeated programs produce symmetric designs?" or simply creating beautiful patterns. Andrea diSessa and I describe some of the mathematics that arises from investigating this computer-based approach to geometry in the book *Turtle Geometry: The Computer as a Medium for Exploring Mathematics* (Cambridge, MA: MIT Press, 1981).

In addition to the subject matter, the *system interaction* also plays a crucial role. When people explore using Logo, they are continually defining new procedures and modifying old ones. A typical compiler-oriented system, in which changing a definition requires switching back and forth among separate editors, compilers, and linking loaders, is inappropriate for this kind of activity. Much of the effort in implementing Logo has gone into providing a programming environment that makes it easy to define and modify procedures. The Texas Instruments and Apple implementations of Logo include integrated screen editors. Giv-

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ing the command TO or EDIT activates the screen editor, with the appropriate procedure definition ready to be modified. A single keystroke installs the new definition as a Logo procedure.

The success of turtle geometry is due in large part to the fact that in designing it we did not view ourselves solely as mathematicians and educators attempting to invent a new approach to geometry, nor as computer scientists attempting to implement a system. Instead, we tried to take both perspectives, continually tailoring the computer system to fit the mathematics, and vice versa.

Outputs

We've already seen how to define procedures that require inputs. You can also make a procedure output a value. For instance, the following procedure takes two numbers as inputs and outputs their average:

```
TO AVERAGE :X :Y
OUTPUT (:X + :Y) / 2
END
```

The result returned by AVERAGE can be examined directly (using PRINT) or used in turn as an input for other operations:

```
PRINT (AVERAGE 2 3)
2.5
PRINT (AVERAGE 1 2) + (AVERAGE 3 4)
5.0
PRINT (AVERAGE (AVERAGE 1 2) 3)
2.25
```

Note the Logo convention of using parentheses to group a procedure with its inputs. Although parentheses are almost always *optional* in simple Logo lines, it is a good idea to include them because they make the lines easier to read.

Programming with Procedures

A Logo program is typically structured as a cluster of procedures. These procedures pass information among themselves by means of inputs and outputs. The advantage of this kind of organization is that it separates the program into manageable pieces, as each procedure can be simple in itself. Even in a complex program, it is unusual to have an individual procedure that is more than a few lines long. In addition, the integrated Logo editor and the general interactive nature of the Logo system enable you to define and test individual procedures separately.

To illustrate procedural organization, let's design a simple game that's played as follows. The computer chooses at random a "mystery point" on the screen, and asks the player to make successive LEFT and FORWARD moves with the turtle. Before each move, the computer prints the turtle's distance from the mystery point. The goal is to get the turtle very close to the point in as few moves as possible. Here's a transcript of the game in action. The computer's responses are printed in italics to distinguish them from what the player types:

```
DISTANCE TO POINT IS 67.6
TURN LEFT HOW MUCH?
0
GO FORWARD HOW MUCH?
25
DISTANCE TO POINT IS 90.25
TURN LEFT HOW MUCH?
180
GO FORWARD HOW MUCH?
50
DISTANCE TO POINT IS 47.38
.
.
.
```

And finally:

```
DISTANCE TO POINT IS 12.08
YOU WON IN 11 MOVES!
```

The heart of the program is a procedure called PLAY. This takes as input a number M, which indicates the number of moves so far. PLAY first checks to see if the player has won. If so, it prints a message saying how many moves have occurred, and stops. Otherwise, it asks the player to make a move, and goes on to the next round, with M increased by 1:

```
TO PLAY :M
TEST CHECKWIN?
IFTRUE (PRINT [YOU WON IN]
     :M [MOVES!])
IFTRUE STOP
MAKEMOVE
PLAY :M + 1
END
```

The PLAY procedure is simple in itself

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Circle 267 on inquiry card.

because it delegates the problems of testing for wins and making moves to the procedures CHECKWIN? and MAKEMOVE.

Here's MAKEMOVE, which prompts the user for angles and distances, and moves the turtle correspondingly. It uses a subprocedure READNUMBER, which returns a number typed in at the keyboard:

```
TO MAKEMOVE
PRINT [TURN LEFT HOW MUCH?]
LEFT READNUMBER
PRINT [GO FORWARD HOW MUCH?]
FORWARD READNUMBER
END
```

To check for a win, the program must test whether the turtle's position is close to some predetermined point (e.g., 20 steps). The Logo primitive operations XCOR and YCOR return the turtle's x and y coordinates. We'll suppose that the x and y coordinates of the hidden point are given by variables XPT and YPT. If you assume there is a procedure DISTANCE that returns the distance between two points, the CHECKWIN? procedure can be written as follows:

```
TO CHECKWIN?
MAKE "D DISTANCE XCOR YCOR
      :XPT :YPT
(PRINT [DISTANCE TO POINT IS]
      :D)
IF :D < 20 OUTPUT "TRUE
OUTPUT "FALSE
END
```

CHECKWIN? returns as its value either TRUE or FALSE, which is the result that is tested by PLAY to determine whether the game is over. Observe also the use of the MAKE statement to assign values to variables. In this case, D is used to designate the distance.

Here is the procedure for computing the distance between two points, as the square root of the sum of the squares of the coordinate differences:

```
TO DISTANCE :A :B :X :Y
MAKE "DX :A - :X
MAKE "DY :B - :Y
OUTPUT SQRT (:DX*:DX + :DY*:DY)
END
```

Now you need a procedure to start the game:

```
TO GAME
CLEARSCREEN
MAKE "XPT RANDOMCOORD
MAKE "YPT RANDOMCOORD
PLAY 0
END
```

This clears the screen, assigns values (chosen at random) to the mystery-point coordinates XPT and YPT, and calls PLAY with an initial M equal to zero.

The following procedure, used to select random coordinates, returns a random number between −75 and +75. It works by calling the Logo primitive RANDOM to obtain a random number between 0 and 150, and subtracts 75 from the result:

```
TO RANDOMCOORD
OUTPUT (RANDOM 150) - 75
END
```

The only thing needed to complete the program is READNUMBER, which returns a number input from the keyboard:

```
TO READNUMBER
OUTPUT FIRST REQUEST
END
```

READNUMBER uses the Logo primitive REQUEST, which waits for the user to type a line, and then returns a list of all the items in that line. The desired number is extracted as the first item of the input list. (We'll talk about lists below.)

Actually, it might be better to design READNUMBER so that it checks to see if the item to be returned is indeed a number, and to complain otherwise:

```
TO READNUMBER
MAKE "TYPEIN FIRST REQUEST
IF NUMBER? :TYPEIN OUTPUT
   :TYPEIN
PRINT [PLEASE TYPE A NUMBER]
OUTPUT READNUMBER
END
```

Notice the final line of the procedure. Its effect is to make READNUMBER try again for an input until it gets a number, as many times as necessary.

This makes the game behave as follows:

```
GO FORWARD HOW MUCH?
FJKSL
PLEASE TYPE A NUMBER
FIFTY
PLEASE TYPE A NUMBER
50
.
.
.
```

Lists

We've seen that Logo's procedural organization makes it an easy and convenient language for writing programs. Most modern programming languages are, in fact, procedurally organized, although few languages make it so easy to interactively define and modify procedures as does Logo.

A much more special aspect of Logo is the way it handles *collections of data*. This is done using *lists*. A list is a sequence of data objects. For example:

```
[1 2 BUCKLE MY SHOE]
```

is a list of five things. The items in a list can themselves be lists, as in:

```
[[PETER PAN] WENDY JOHN]
```

which is a list of three items, the first of which is itself a list of two items. Similarly, we can have lists whose items are lists, and so on. Lists, therefore, are a natural way to represent *hierarchical structures*, that is, structures composed of parts that themselves are composed of parts.

Logo includes a number of operations for manipulating lists. FIRST extracts the first item of the list. In this example:

```
FIRST [1 2 BUCKLE MY SHOE]
```

it is 1, and in the next example:

```
FIRST [[PETER PAN] WENDY JOHN]
```

it is [PETER PAN].

The BUTFIRST operation returns the list consisting of all but the first item of the given list, so in

```
BUTFIRST [1 2 BUCKLE MY SHOE]
```

it is [2 BUCKLE MY SHOE], while in

```
BUTFIRST [[PETER PAN]
    WENDY JOHN]
```

it is [WENDY JOHN].

The FPUT operation takes the two objects x and y and constructs a list whose FIRST is x and whose BUTFIRST is y. For example:

```
FPUT 5 [2 BUCKLE MY SHOE]
```

produces the list [5 2 BUCKLE MY SHOE], and

```
FPUT [PETER PAN]
    [BUCKLE MY SHOE]
```

produces the list [[PETER PAN] BUCKLE MY SHOE].

The SENTENCE operation, like FPUT, constructs larger lists from smaller ones, but in a slightly different way. SENTENCE takes a number of lists as inputs and combines all their elements to produce a single list. For example:

```
SENTENCE [PETER PAN]
    [BUCKLE MY SHOE]
```

produces the list [PETER PAN BUCKLE MY SHOE].

The significant thing about lists in Logo is that they can be manipulated as what computer scientists call "first-class data objects." That is to say, Logo lists (as opposed, for example, to arrays in BASIC) can be:

- assigned as the values of variables
- passed as inputs to procedures
- returned as the outputs of procedures

For instance, you can assign names to lists:

```
MAKE "X [OOM PAH]
MAKE "Y [HEIGH HO]
```

and then refer to the values of these variables, so that BUTFIRST :X is the list [PAH]. You can also combine operations on lists to produce more complex operations. For example:

```
FIRST FIRST [[PETER PAN]
    WENDY JOHN]
```

returns the word PETER.



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You can also write procedures that manipulate lists:

```
TO DOUBLE :L
OUTPUT SENTENCE :L :L
END

PRINT DOUBLE [OOM PAH]
OOM PAH OOM PAH

PRINT DOUBLE DOUBLE
      [OOM PAH]
OOM PAH OOM PAH
      OOM PAH OOM PAH
```

The implication of this is that you can combine operations on lists, much as you combine operations on numbers in ordinary languages. For example, one very useful list operation is PICKRANDOM, which chooses an item at random from an input list. PICKRANDOM is not provided as a primitive operation, but is easily constructed out of simpler operations, such as finding the length of a list, selecting a random number in a given range, and extracting the *n*th item of a list.

Playing with Text

To illustrate how lists are used, let's examine a program that composes vacation postcards, such as:

```
DEAR DOROTHY
WISH YOU WERE HERE.
LOVE -- JOHN

DEAR MARY
EVERYONE'S FINE.
WRITE SOON -- AUNT EM
```

You begin by setting up lists of names and phrases from which the elements of the postcard will be chosen:

```
MAKE "NAMES
      [JOHN
       DOROTHY
       [AUNT EM]
       OCCUPANT]
MAKE "PHRASES
      [[WISH YOU WERE HERE.]
       [WEATHER'S GREAT!]
       [SURF'S UP.]
       [EVERYONE'S FINE.]]
MAKE "CLOSINGS
      [LOVE
       [SEE YOU SOON]
       [WRITE SOON]]
```

Here's the main postcard program:

```
TO POSTCARD
PRINT SENTENCE [DEAR] NAME
PRINT BODY
PRINT (SENTENCE CLOSING
      [--] NAME)
POSTCARD
END
```

The recursive call in the last line makes the procedure keep printing new postcards over and over. (Compare the SQ and POLY procedures.)

The procedures NAME, BODY, and CLOSING generate the elements of the postcard by selecting items from the appropriate lists:

```
TO NAME
OUTPUT PICKRANDOM :NAMES
END

TO BODY
OUTPUT PICKRANDOM :PHRASES
END

TO CLOSING
OUTPUT PICKRANDOM :CLOSINGS
END
```

You can change the postcard program so that it automatically augments its repertoire of phrases by every so often (say, one chance in three) asking the user to type in a new phrase and adding that to the PHRASES. To do this, add to the POSTCARD procedure the line:

```
IF 1.IN.3 LEARN.NEW.PHRASE
```

The 1.IN.3 procedure returns TRUE with odds of one chance in three and FALSE otherwise. One possible way to write this procedure is:

```
TO 1.IN.3
IF (RANDOM 3) = 0 OUTPUT "TRUE
OUTPUT "FALSE
END
```

Here's how the program learns a new phrase:

```
TO LEARN.NEW.PHRASE
PRINT [PLEASE TYPE IN A NEW PHRASE]
MAKE "PHRASES FPUT REQUEST
  :PHRASES
END
```

The idea is that REQUEST returns (as a list) the phrase that the user types in response to the message. This is added to PHRASES (by means of FPUT), so that the program will be able to use this phrase in future postcards, like:

```
PLEASE TYPE IN A NEW PHRASE
DON'T FORGET TO FEED THE DOG.

DEAR OCCUPANT
DON'T FORGET TO FEED THE DOG.
LOVE -- JOHN
.
.
.
```

Another change you can make is to generate longer postcards, whose BODY consists of one or more phrases. One way to do this is to alter the BODY procedure as follows:

```
TO BODY
IF 1.IN.2 OUTPUT SINGLE.PHRASE
OUTPUT SENTENCE BODY
      SINGLE.PHRASE

TO SINGLE.PHRASE
OUTPUT PICKRANDOM :PHRASES
END
```

This uses recursion in a devious way. Half the time you call BODY, it will output a single phrase, just as before. (The procedure 1.IN.2 is analogous to the 1.IN.3 procedure above.) But the other half of the time, it recursively generates a new BODY and combines this (using SENTENCE) with a single phrase. The new (recursively called) BODY will itself generate a single phrase only half the time. Otherwise, it will call a *third* BODY. The result is that a call to body will generate a single phrase about half the time, two phrases about one-fourth of the time, three phrases about one-eighth of the time, and so on.

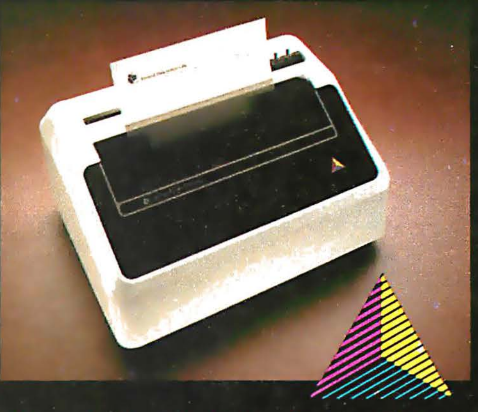
Here's the final postcard program in action:

```
DEAR AUNT EM
SURF'S UP. DON'T FORGET TO
      FEED THE DOG.
WRITE SOON -- DOROTHY

PLEASE TYPE IN A NEW PHRASE
GET THE MONEY IN SMALL BILLS.

DEAR OCCUPANT
WEATHER'S GREAT! WISH YOU
      WERE HERE. GET THE
      MONEY IN SMALL BILLS.
SEE YOU SOON -- JOHN
.
.
.
```

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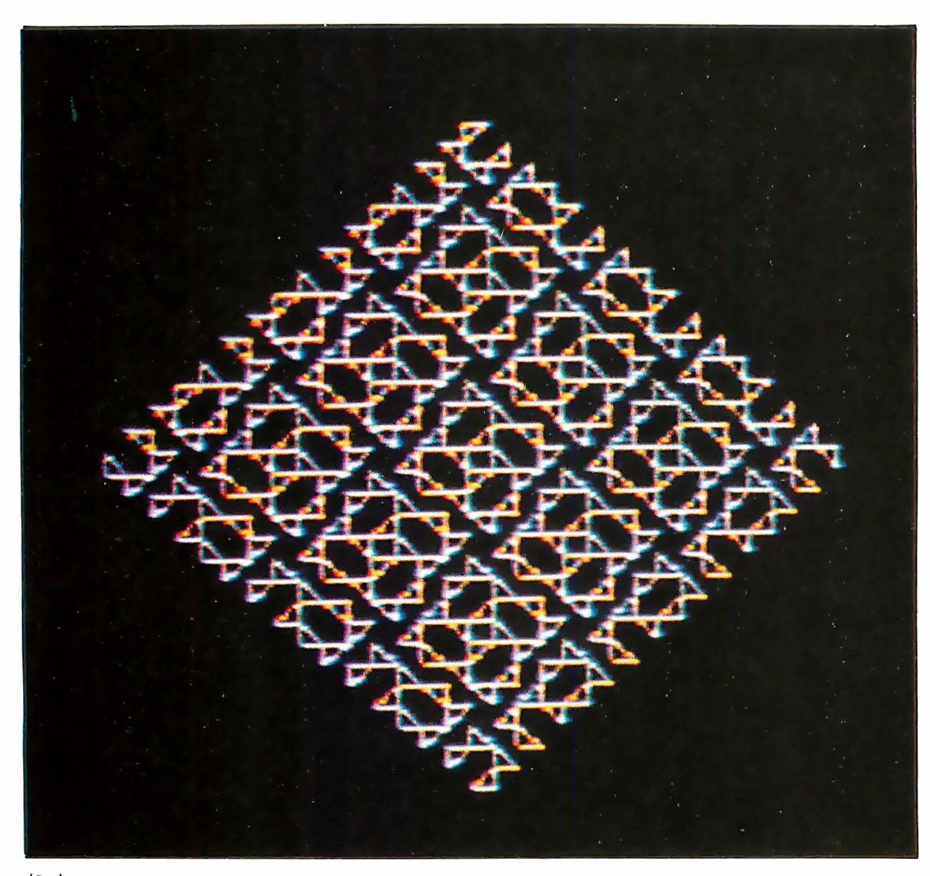
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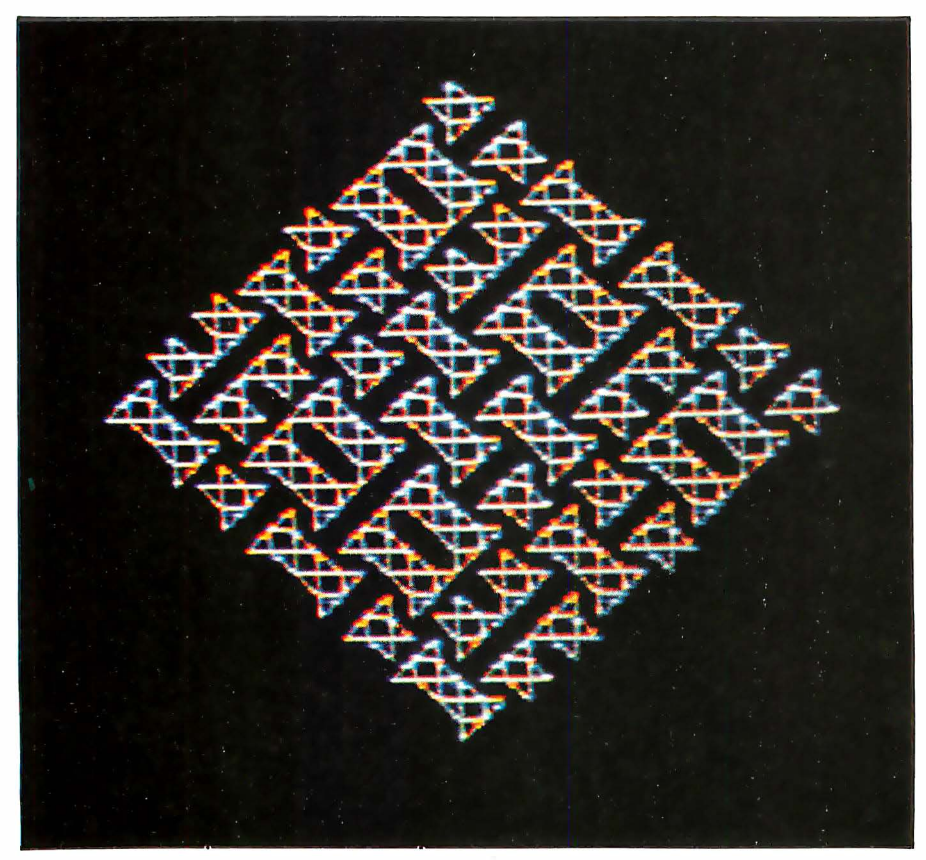
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(2a)



(2b)

Photos 2a and 2b: *Two tiling patterns constructed from the same basic figure (a triangle within a square). The differences in the patterns are due to using different orientations when the basic figure is combined into "higher-level" patterns.*

Text-generation procedures are fun to write and to play with and also easy to modify. You can make them as elaborate or as simple as you like and apply the same ideas to producing essays, poems, love letters, and so on. The idea of generating a random postcard program is based on work done at MIT by Neil Rowe, whose article "Grammar as a Programming Language" (*Creative Computing*, January/February 1978) contains many other examples of text-generation procedures. It also shows how to implement, in Logo, a special-purpose "sublanguage" for creating such programs.

Recursive Tiling

The success of Logo as a catalyst for learning involves much more than the Logo language itself, although the language does play a crucial role. The best kind of Logo activity is a synthesis of programming, mathematics, aesthetics, and, above all, the opportunity to explore. One particularly striking example of this is the "recursive tiling" program invented by Andrea diSessa and Doug Hill. This scheme enables you to write simple procedures that draw patterns such as the ones shown in photos 2 and 3, giving you literally billions of possibilities to examine and explore.

The idea is as follows. Suppose you have a program that draws a pattern inside a square of some given size. By scaling the pattern size in half and gluing together four copies, you obtain a more complex pattern in the a square of the original size, as shown in figure 5a on page 108. In fact, you can generate many different patterns from a single pattern because each copy of the original pattern that you place in each corner square can be rotated through an arbitrary multiple of 90 degrees, as shown in figure 5b.

To convert this idea into a computer program, suppose you have a procedure called PROC that draws a pattern in a square. Assume that PROC takes an input S that specifies the size of the square, scaled so that S is equal to half the diagonal of the square. Assume also that PROC is designed to begin drawing with the turtle at the center of the square pointing

at a vertex, and to end with the turtle in the same state.

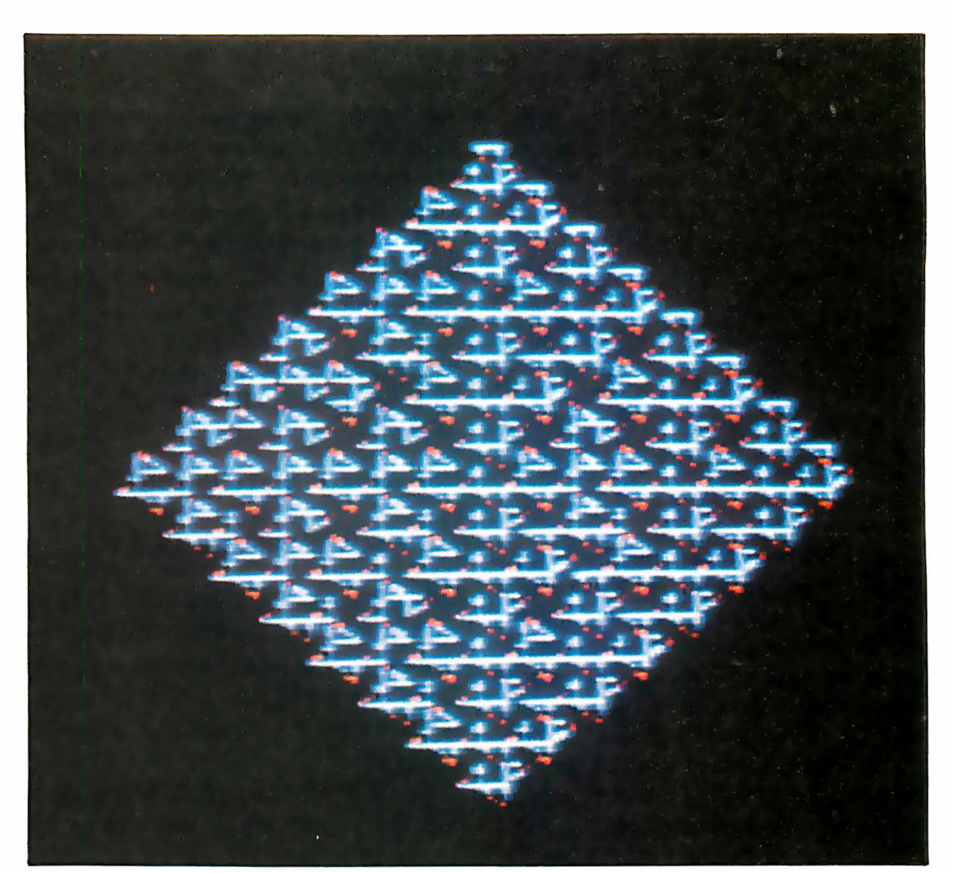
Now suppose you have a square of size S divided into four "corner squares" each of size S/2. The following process is designed to start with the turtle at the center of the square, facing one of the corners. It draws a copy of the PROC design in that corner square and returns the turtle to the center of the larger square. Then it turns the turtle 90 degrees to point at the next corner square. The steps in the process are:

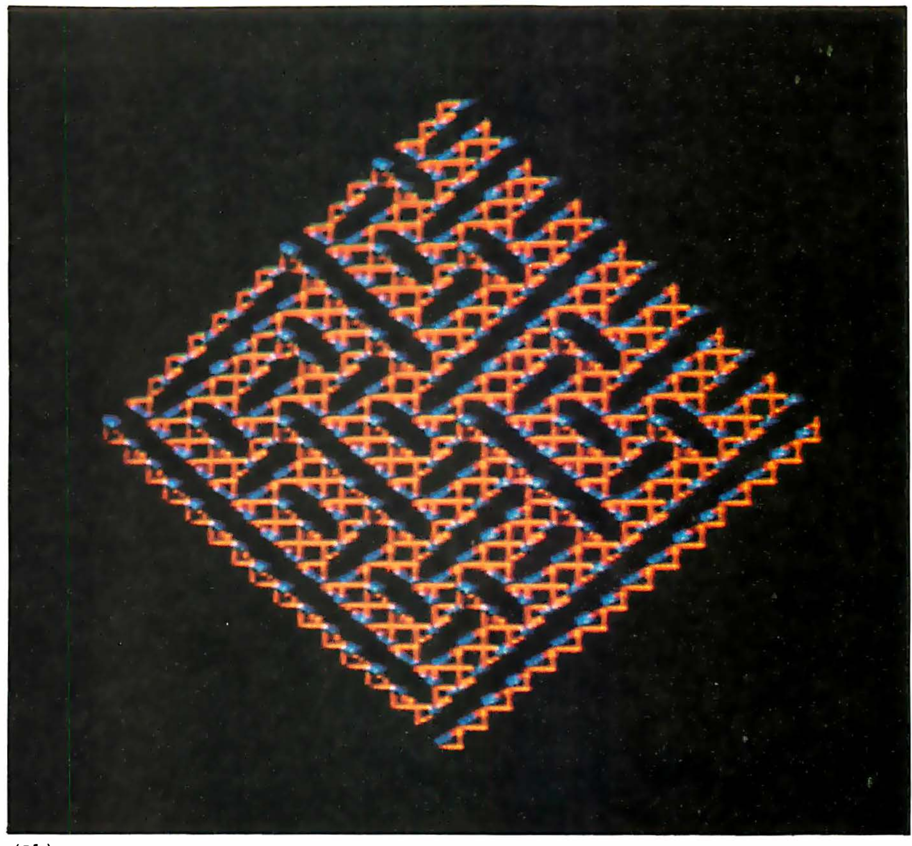
1. Move the turtle FORWARD a distance of S/2. This brings the turtle to the center of the small square, pointing at a vertex of *that* square.
2. Run the procedure PROC with an input of S/2 (half the diagonal of the smaller square). This draws the pattern and leaves the turtle at the center of the small square.
3. Move the turtle BACK a distance of S/2 to return it to the center of the larger square.
4. Rotate the turtle 90 degrees.

In addition, before performing step 2, you can rotate the pattern through a multiple of 90 degrees. If you do this, you should perform the opposite rotation at the end of step 2, so that the turtle will end up facing in the same direction from which it started.

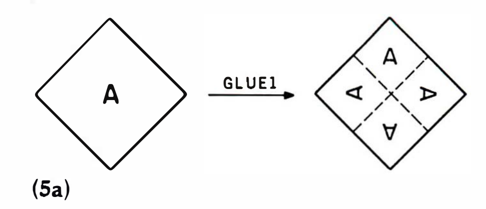
The following CORNER procedure implements this strategy. CORNER takes three inputs. The first, A, is a multiple of 90 degrees to be turned before drawing the pattern (A is an integer from 0 to 3). The next input, PROC, is the name of the procedure that draws the pattern. PROC is assumed to take one input that specifies the size of the pattern. The third input to CORNER is a number S that specifies the size of the square. The procedure is used as follows:

```
TO CORNER :A :PROC :S
FORWARD :S/2
RIGHT 90 * :A
DRAWFIGURE :PROC :S/2
LEFT 90 * :A
BACK :S/2
RIGHT 90
END
```

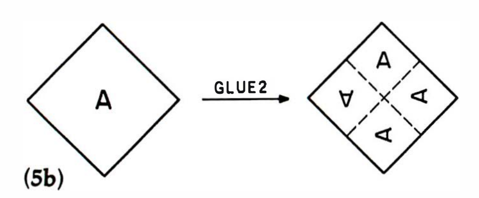

(3a)


(3b)

Photos 3a and 3b: *Two tiling patterns constructed on the same basic triangle as in photos 2a and 2b. All four patterns use the gluing scheme shown in figures 5a and 5b, and photos 4a, 4b, and 4c, extended to four levels.*



(5a)



(5b)

Figure 5: *Given a design that lies inside a square, four copies of the same design (each scaled to half the size of the original) will produce a more complex pattern in the same square. Varying the relative orientations of the four copies produces different overall designs. This is the basic gluing scheme used to produce the patterns in photos 2a, 2b, 3a, and 3b, starting with a triangle, and repeating the gluing process four times (i.e., working with a final pattern element scaled to 1/16 times the size of the original square).*

The CORNER procedure uses a subprocedure DRAWFIGURE, which takes as inputs a procedure name and a number and runs the procedure with the number as input. DRAWFIGURE is implemented in terms of the Logo primitive operation RUN, which executes a list as if it were a typed-in command line:

```
TO DRAWFIGURE :PROC :INPUT
RUN SENTENCE :PROC :INPUT
END
```

For example, if you execute:

```
DRAWFIGURE [SQUARE] 100
```

this combines [SQUARE] and 100 to obtain the list [SQUARE 100] and executes this list as if it were a typed-in Logo command line, which is to say, it executes the command SQUARE 100.

The CORNER procedure begins with the turtle pointing at one corner of the large square; it ends with the turtle pointing at the next corner. This means that you can obtain a complete gluing design by running CORNER four times. Each of the four calls to CORNER can specify a different 90-degree multiple of A, through which the design in that corner should be rotated. Since each gluing has four corners, and each corner can have any of four rotations, there are 4^4 or 256 possible gluings for any given pattern. Here are two possible gluings:

```
TO GLUE1 :PROC :S
REPEAT 4 [CORNER 0 :PROC :S]
END

TO GLUE2 :PROC :S
CORNER 0 :PROC :S
CORNER 2 :PROC :S
CORNER 1 :PROC :S
CORNER 3 :PROC :S
END
```

Photo 4b shows the result of entering

```
GLUE1 [TRI] 100
```

where TRI is a procedure that draws a small triangle inside a square, as





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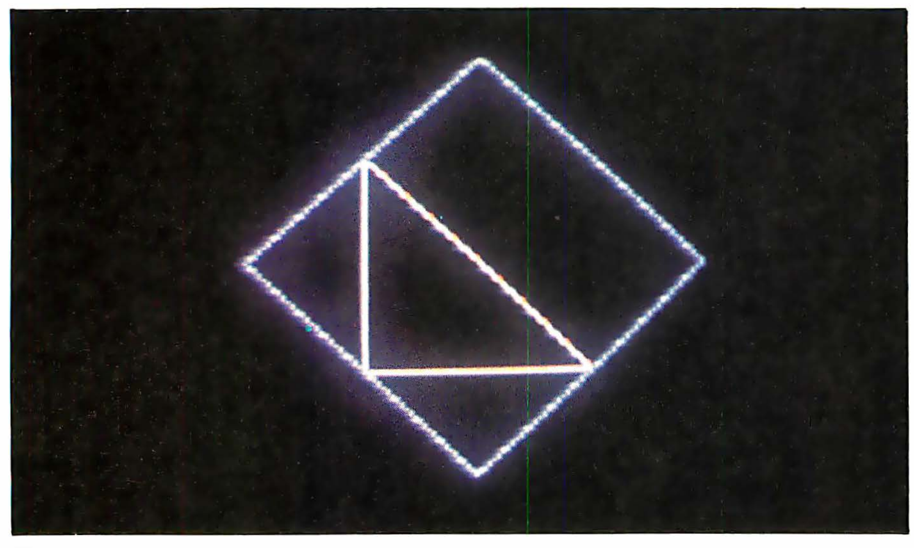
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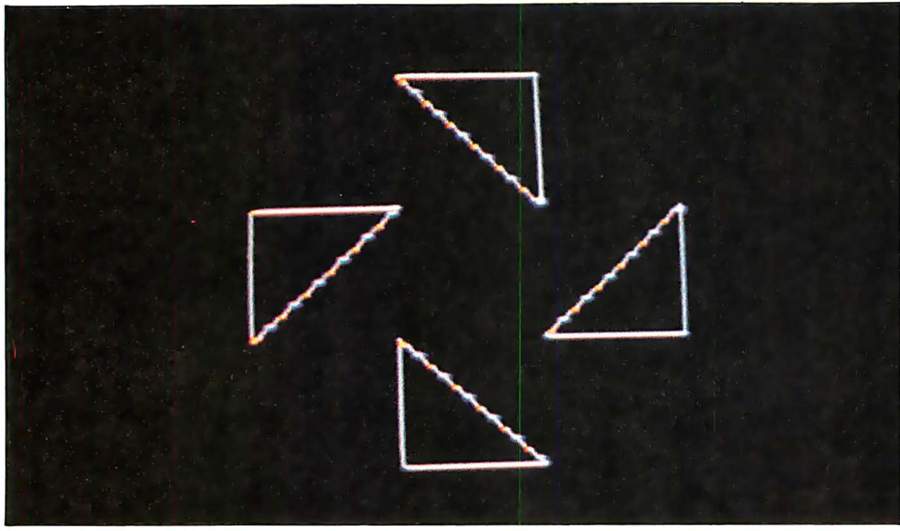




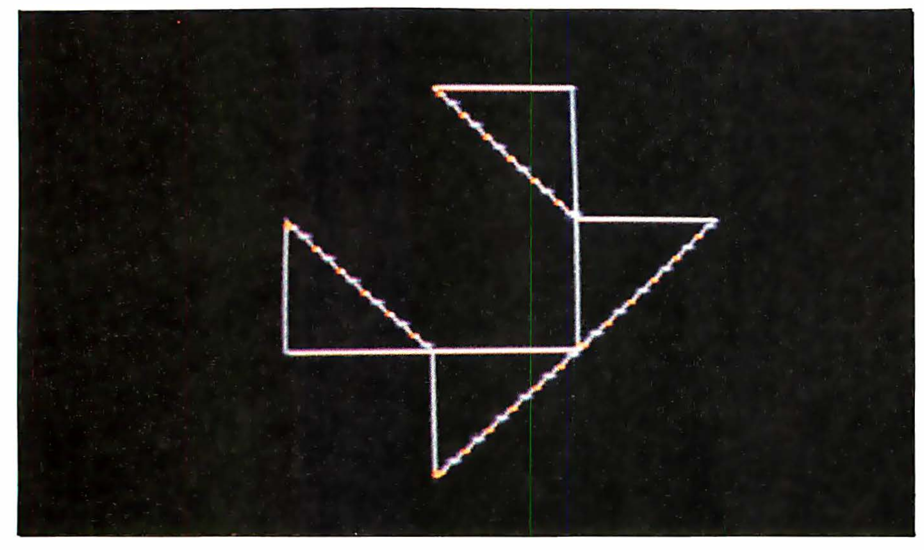
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(4a)



(4b)



(4c)

Photo 4: *Photo 4a shows a triangle inside a square, as drawn by the procedure* TRI. *(The square, shown here in color, is not drawn by* TRI. *Photos 4b and 4c show two different one-level gluings of the* TRI *procedure to form a more complicated figure inside a square. The complex designs in photos 2a, 2b, 3a, and 3b are four-level gluings based on the same* TRI *figure.*

shown in photo 4a. (In accordance with general gluing strategy, TRI should be a procedure that takes one input that specifies the size of the square.) For comparison, photo 4c shows a different gluing:

GLUE2 [TRI] 100

Now comes the clever idea. The GLUE procedures enable you to glue together four copies of any pattern. On the other hand, entering

GLUE1 [TRI] 100

is *also* a command that draws a pattern in a square. In fact, the list [GLUE1 [TRI]], when combined with a size (via the DRAWFIGURE procedure), produces a command that draws a pattern in a square of the specified size. Therefore, you can use a GLUE procedure to glue together four of *these* patterns, for example:

GLUE1 [GLUE1 [TRI]] 100

or

GLUE2 [GLUE1 [TRI]] 100

But again, each of these "two-level" gluings is *itself* something that can be glued, so you can make three-level patterns such as

GLUE2 [GLUE1 [GLUE2 [TRI]]] 100

and so on and so one. The patterns shown in photos 2a, 2b, 3a and 3b are, in fact, all four-level gluings based on the same TRI procedure, using different rotations at the various levels.

There's an enormous range of possibilities to investigate here. Four levels of gluings with 256 orientation choices at each level give 256^4 or more than 4 billion possible four-level gluings, all from a single base pattern! (The number of distinct patterns is reduced by various symmetries in the gluing process, which is itself an interesting phenomenon to explore.) For more variety, you can try different base patterns, or even develop different gluing schemes, such as the one derived from dividing an equilateral triangle into four smaller equilateral triangles. (See *Turtle Geometry*

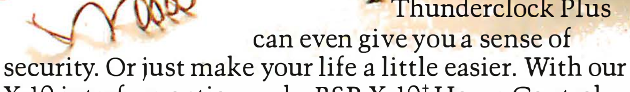
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for more investigations with "recursive designs.")

The Computational Perspective

Logo is often described as a programming language. Those of us who designed Logo tend to think of it rather as a computer-based learning environment, where the activities (exploring the symmetry of POLY) are just as integral as the programming tools used (recursion and lists). Logo is also a continually evolving environment, and the microcomputer implementations of Logo that have appeared during the past year are only the first to be widely available. We plan to extend Logo to incorporate new linguistic features, such as the "message passing" facilities found in Smalltalk and recent implementations of LISP (see the August 1981 issue of BYTE for an overview of Smalltalk), as well as new activities, such as a computer-based physics curriculum that builds upon turtle geometry. At the MIT Laboratory for Computer Science, the Educational Computing Group is designing a follow-on system to Logo suitable for the new generation of personal computers that will be coming into use during the latter half of the 1980s.

The next few years will be exciting ones in educational computing because personal computers are becoming powerful enough to support systems that are designed for the convenience of people rather than for the convenience of compilers. If we can dispel the delusion that learning about computers should be an activity of fiddling with array indexes and worrying about whether *X* is an integer or a real number, we can begin to focus on programming as a source of *ideas*. For programming is an activity of *describing* things. The descriptions are phrased so that they can be interpreted by a computer, but that is not really so important. Computational descriptions, like those of science or mathematics, provide a perspective, a collection of "tools of thought," such as procedural organization, hierarchical structure, and recursive formulations. Logo, and languages like it, will help make these tools available to everyone. ■



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Logo in the Schools

Putting Logo in the classroom has led to some interesting results.

Daniel Watt
Editor, BYTE Books

In the 15 years since its development, the Logo computer language has been used in a variety of research and educational settings. Students from preschool to graduate school; those with severe physical, mental, and emotional handicaps; and students with outstanding ability in science and mathematics have been involved with Logo. It has been used in educational settings to:

- provide an environment for experiential learning of mathematics
- promote the development of problem-solving abilities
- serve as an introductory programming language that helps students learn principles of structured programming
- serve as a vehicle for computer literacy, helping students develop a sense of personal control of a computer
- support the learning of students who, for one reason or another, have not been successful in traditional classrooms
- provide the basis for learning environments in a number of subject areas, including music, language arts, fine arts, physics, biology, and mathematics
- form a foundation for an entirely new kind of school based on Piagetian approaches to teaching and learning, using computers as all-purpose tools to facilitate learning

Each time Logo has been introduced into a school, certain objectives have been emphasized at the expense of others. This article deals with four different Logo projects and describes the settings, the goals of each project, and some of the known results. In some cases, I have drawn on the published reports listed in the references. Where published reports are not available, I have relied on visits and interviews with people directly involved. Each of the projects has had many dimensions that are not included here because of space limitations. For further information, read the reports cited in the references or contact the projects.

Each project had a different type of student population, different choice of goals, and different kinds of results.

The Edinburgh Logo Project, Department of Artificial Intelligence, University of Edinburgh, Edinburgh, Scotland, dealt with 12- and 13-year-old boys attending a private school adjacent to the university. It focused on the use of Logo to create an environment for learning to think mathematically and on developing new methods to teach the content of conventional school mathematics.

The Brookline Logo Project, conducted as a collaboration between the MIT Logo Group and the public

About the Author

Daniel Watt, a former elementary-school teacher, was involved in curriculum development and the Brookline Logo project at MIT. Watt holds a doctorate in engineering from Cornell University and is currently an editor with BYTE.



Photo 1: *Preschool students using TI Logo at the Lamplighter School, Dallas, Texas. Photo courtesy of Texas Instruments Inc.*

schools of Brookline, Massachusetts, had two very different phases. In the first, a laboratory was set up with four computers. The emphasis of the research was to observe and document what a group of sixth-grade students actually learned, rather than assess whether they had achieved a set of preplanned objectives.

The second phase of the Brookline Logo Project involved placing computers in fourth- through eighth-grade classrooms for several weeks at a time. This project emphasized the development of curriculum materials to support the learning of Logo as one activity in a multifocused classroom.

The Computers in Schools Project, conducted by the New York Academy of Sciences in conjunction with the New York Public Schools, provided training for elementary and junior high school teachers to use Logo as a permanent feature of their classrooms. The major focus of this project has been implementation in the school, training and supporting teachers to ensure successful use of Logo in the classroom.

The Lamplighter School Logo Project, conducted at a private school in Dallas, Texas, for students aged 3 to 9, is the most ambitious Logo project to date. Conducted as a joint effort with the school, the MIT Logo Group, and Texas Instruments, the project was intended to provide the school with enough computer hardware that access to computers would not be a limitation on what the students could learn. Logo would be taught to all students and teachers, from nursery school through grade four. Eventually, the project was expected to enhance learning in many areas as it facilitated the use of the computer as a multipurpose learning tool throughout the curriculum. The Lamplighter School also served as the primary test site for the development of the Texas Instruments implementation of Logo.

The Edinburgh Logo Project

The objective of the Edinburgh Logo Project was to discover whether the students' ". . . ability to do mathematics and to talk about their mathematics was changed by exploring mathematical problems through [Logo] programming." The quotes in this section are taken from *Teaching Mathematics Through Logo Programming: An Evaluation Study,* by Howe, O'Shea, and Plane (see references section 1). The students were a group of 11 sixth-grade boys from the George Herriot School, a private school near the university. They were selected from the school's lowest-level math group.

The project lasted for two years, during which the students attended a Logo lab at the university. For the first year, the students worked through a set of graded worksheets to learn the basic elements of Logo. For the second year, they did special Logo exercises designed to teach topics

selected from their regular mathematics curriculum.

The project was highly structured in several respects. The students' learning experiences were structured by means of assigned worksheets that they worked through in order, each at his own rate. In this way, researchers could effectively monitor the progress of each student. During the second year of the project, Logo activities were drawn from mathematical topics such as areas of rectangles, factors and multiples, positive and negative numbers, and plotting coordinates on graphs.

The research aspect of the project was also carefully structured. Students were given standardized tests in mathematics before and after the project. Their progress was compared with that of a control group (drawn from boys in the second lowest-level math group). Both groups of boys, as well as their teachers, were also given a series of questionnaires designed to measure their attitudes toward mathematics. Great care was taken to see that the research design was carefully carried out.

The published results of the project on student achievement were not very dramatic. Over the two years,

Teachers found that students who had taken part in the Logo classes were more willing to "argue sensibly about mathematical issues" and to explain their "mathematical difficulties clearly."

the experimental group improved a bit more than the control group on a "basic maths" test. The reverse was true on a "maths attainment" test. The most interesting finding had to do with the teachers' perceptions of the students in both groups. Teachers found that students who had taken part in the Logo classes were more willing to "argue sensibly about mathematical issues" and to explain their "mathematical difficulties clearly." This finding may have depended as much on the teaching approach used by the Logo teachers—as compared with the classroom mathematics teachers—and on the individual assistance the Logo students received, as it did on the Logo activities themselves.

Conversations with some of the people involved indicate that a lot of interesting data about what and how the students learned was collected during this project. Unfortunately, little of that information has been analyzed or published. For people interested in teaching Logo, the most tangible results of the project may be the sets of worksheets developed to teach Logo concepts and mathematical applications. These represent a useful set of Logo teaching ideas—even if they are not used in the strictly

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sequential format for which they were originally designed. Copies of student worksheets used in both years of the project are available from the Edinburgh Logo Group.

The Edinburgh Logo Group has also been involved in several other educational projects. In one project, student teachers who were not math specialists were taught Logo to see how it would affect their teaching of mathematics. In another project presently under way, computers have been installed in several schools so that the Logo curriculum can be taught by classroom teachers who have taken a Logo training course. This project is intended to give clearer results about the impact of Logo on the improvement of classroom performance in mathematics.

In order to carry out the current study, the Edinburgh Logo Group implemented a version of Logo on the Terak computer system, an LSI-11-based system with high-resolution graphics. Disks for this version of Logo are available from the Edinburgh Logo Group. Other Logo implementation projects are under way for microcomputer systems widely available in Great Britain.

The Brookline Logo Project

The first Brookline Logo Project, funded by the National Science Foundation and conducted by the MIT Logo Group in collaboration with a public school in Brookline, Massachusetts, had a very different set of goals and results. In this case, 50 sixth-grade students were given the opportunity to learn Logo in a computer lab established within the school. The work of 16 of these students, representing a full range of academic abilities and interests, was selected for study.

The entire Logo learning experience of these students was carefully monitored and analyzed, documenting what the students learned, what learning styles they used, and what types of choices they made. Some common material and ideas were presented to all the students and introductory turtle geometry projects were stressed at the beginning of the project. Students also had the opportunity to choose their own activities and went on to develop many different Logo projects, including a math quiz, word games and conversations, animations, geometric explorations, tic-tac-toe, and dynamic action games. The students were expected to be in charge. The teachers were there to help them accomplish their own goals.

The results of the project indicate that Logo learning environments are suitable for many different kinds of students. All students, ranging from those who were academically gifted to those who had the poorest academic records, were successful in the Logo classes. The surprising success of students with learning disabilities led to a separate proposal to provide Logo training and equipment for teachers who specialized in this area. The final report of the project summarized the students' learning styles and analyzed what they learned in the areas of computer programming and mathematics. A second volume of the report traced the learning experiences of each of the 16 students individually. The report provides a basis for an introductory Logo curriculum, as well as a rich source of project ideas suitable for students with widely divergent interests and abilities.

The Brookline Logo Project was not very successful in obtaining "objective" data about learning gains made by the students. Standardized tests had been rejected as irrelevant to the goals of the project (the ability to use turtle geometry is not measured by sixth-grade math tests). The problem-solving tests and mathematical tests devised and administered by the project staff had inconclusive results. The problem of developing objective tests in such areas as problem solving or procedural thinking is still an open question for educational researchers.

Another limitation of the project was that it required an extremely sensitive and knowledgeable teacher, with a great deal of time to consider the needs of each student. It was the



hope of the project staff that the two-volume report, with its analysis of student learning and many examples of student projects, could be an effective resource for teachers working in less ideal settings. The report was also intended as the basis of a Logo curriculum to be developed in subsequent projects.

The second Brookline Logo Project was also funded by the National Science Foundation to develop a curriculum supporting classroom use of Logo. Computers were placed in classrooms from grades four through eight. Teachers were provided with a small amount of training, and the project developed curriculum materials to be used by students and teachers. During the project, two computers circulated among several classrooms. Each classroom had exclusive use of a computer for 8 to 12 weeks. During this time, students worked on their own at the computer, individually or in pairs, while the rest of the class went on with its regular work. About once a week, the entire class met for a lesson at which ideas would be shared, new concepts introduced, and assignments given.

The curriculum materials developed by the project are at two different levels: an introductory Logo curriculum for grades four through six, and a set of advanced Logo projects based on playing and modifying a set of "dynaturtle" games. The introductory curriculum includes step-by-step instructions for students, as well as a number of different types of project ideas. Teachers are given information about everything from the physical arrangement of the computer in the classroom to the concepts the students will be learning, suggestions for whole class lessons, and a checklist to help them monitor student progress.

The advanced activities focus on a series of dynaturtle games that can be used in two different ways. The games provide a microworld in which students can explore the behavior of the dynaturtle—a Logo turtle that has been programmed to follow Newton's Laws of Motion. Each game introduces a new factor to be considered. The first game involves making the dynaturtle hit a target, which forces a student to learn to control its momentum and understand something about how the vector quantities of force and momentum are combined. The second game involves driving the dynaturtle around a circular racetrack, introducing some of the concepts involved in orbital motion. The third game, a version of the familiar Lunar Lander, introduces the effect of gravity. The booklet accompanying the games contains many suggestions and challenges for the students that are designed to help them understand the physics concepts embedded in the games. (Also, see R. W. Lawler's "Designing Computer-Based Microworlds," in this issue on page 138.)

Another method for using the dynaturtle games is as a programming project. The games are deliberately designed to be simple so that they lend themselves to many obvious improvements. Every student who has played them has had ideas for making them better and more interesting. A student booklet

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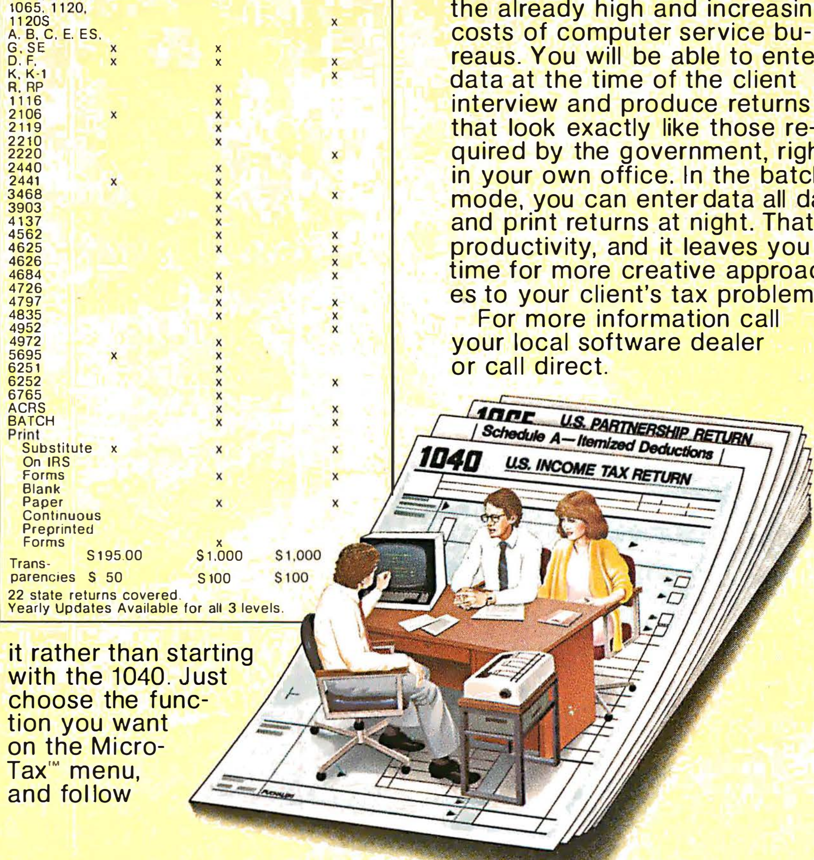
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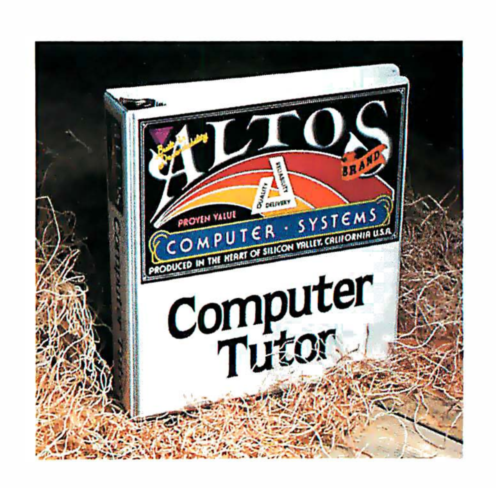
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provides detailed suggestions for making a series of changes in each game. Students who have already learned simple Logo programming can learn some of the intermediate features of the programming language while using these games as models for the construction of elaborate programs from small modules. Students who have gone through these projects are ready to tackle any number of interactive programming projects of their own devising.

Curriculum materials developed during the project are not yet publicly available. The MIT Logo Group is seeking a commercial publisher for them in accordance with the requirements of the National Science Foundation.

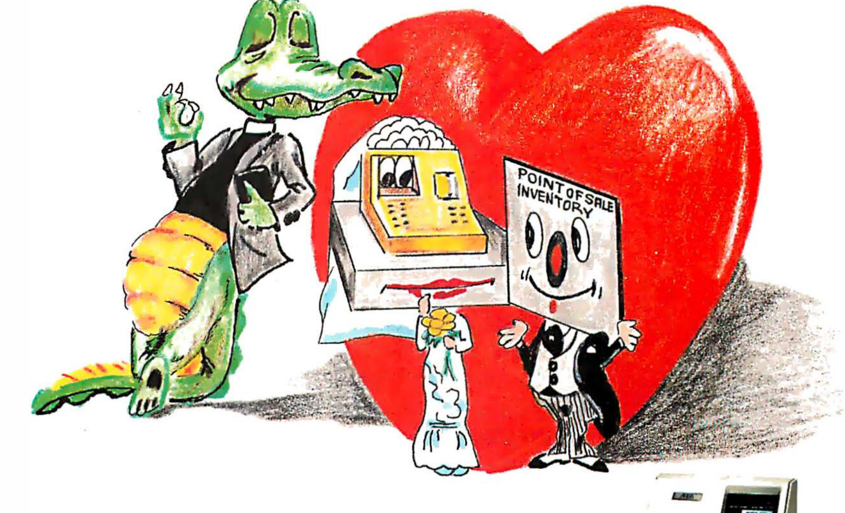
One of the most interesting aspects of the second Brookline Logo Project was the way in which students emerged as Logo teachers. Because there was a group of "student experts" at the beginning of the project, seventh graders who had participated in the first project, teachers incorporated these students as tutors into their planning from the start.

As the project went on, certain students from this group (and others) became known as experts at Logo programming and at managing the computer systems. Teachers throughout the school routinely began to ask these students for help when necessary. When the youngest students in the school, the fourth graders, were introduced to Logo, each student was assigned an upper-grade tutor for the first few weeks. Thus, the fourth graders developed a quick proficiency with the mechanics of the system and were able to begin their own projects very quickly.

A related aspect of the project was the way that students in the same classroom worked together on Logo activities. During the first Brookline Project, student interaction had been limited by the arbitrary manner in which groups were assigned to the laboratory. In the classrooms, students formed natural groupings to share ideas and help each other. Project ideas and "secret knowledge" of how to do certain things were passed among the students by word of mouth. The result of using students as teachers and working partners was a reduction in the teachers' role as source and authority, and the creation of a student-based Logo culture.

It had been assumed at the start that *teacher* knowledge would be a major limiting factor in what the students could achieve. It turned out that this was not the case. The limitations on *student* knowledge were what limited what other students could learn. A strategy was devised to support the transfer of knowledge from student to student. Once a week, an after-school student interest group met to work on projects and share ideas. This gave the students involved an opportunity to further their own Logo knowledge, to increase their store of project ideas, and to develop more consistent ways of thinking about how Logo works. All this made them much more effective in their informal role as spreaders of the Logo culture.

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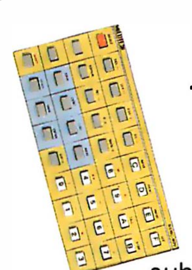
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primarily on curriculum development, there was no opportunity for a study of the role of students as teachers and the impact of this on the roles of classroom teachers as traditional authority figures and sources of all school learning. This type of situation is becoming quite common; students know more about the computers than their teachers because they have more time to develop and share their expertise. The use of students as teachers should be a serious consideration for teachers, researchers, and curriculum developers as computers continue to spread into the schools.

Computers in the Schools—New York City

The Computers in the Schools Project, conducted by the New York Academy of Sciences in collaboration with New York City School Districts 2, 3, and 9, provides teachers with training and support to teach Logo in their own classrooms. The project involves students in grades two through nine from a full range of socioeconomic backgrounds. Like the second Brookline Project, the computers are located in elementary and middle school classrooms. A major difference is that the teachers have had an extensive training period and each classroom is assigned a computer for the entire year.

The project began in the summer of 1980 with a three-week training program for 11 teachers and a principal. An expanded training program in the summer of 1981 included eight more teachers from each of the three school districts. During the year, project staff members made weekly visits to each participating classroom. Teachers also attend a monthly seminar held at the New York Academy of Sciences.

Although the project has not yet published any progress reports, the staff believes it has been successful in

90 to 95 percent of the classrooms involved. In a conversation with project coordinator Michael Tempel, he defined "success" in the following terms: "The positive educational benefit was obvious! Kids were engaged in valid intellectual and social processes. You could see them developing. . . . We have seen striking changes in kids' relationships to schools and learning; kids who had not been successful in school got turned on."

Like the second Brookline project, the Computers in the Schools Project found that interaction among students has been a major positive consequence of having Logo in classrooms. Although Tempel stressed that to remain effective the Logo environment requires "measured and periodic input from the teacher," he has been struck by how much work the students do without teacher intervention. The activity "has a real quality of self-sufficiency" for the students.

One important condition of the project has been the insistence that each classroom have at least one computer for an entire year. Tempel believes that access to computers has been a major element in the success of the project. Another condition was that all the teachers involved had to volunteer for the project and take the summer training without additional pay. This helped ensure that teachers had a direct personal stake in the project. Such factors should not be underestimated when comparing this to other Logo projects or considering it as a model for implementing Logo in other school districts.

When the formal project ends this year, the teachers who have already been trained are expected to carry out future training and support activities on their own. Teachers in each of the three districts will have the responsibility for training and support in their own district. The Logo Learning Center, established by Logo Computer Systems Inc., will function as an informal meeting place, providing a mechanism for teachers to stay in touch, share ideas, and receive additional training.

The future of the Computers in the Schools Project itself involves an ambitious proposal to create a "magnet school" for the three districts in which the students would have access to computers from the earliest grades. With specially trained volunteer teachers, the school would be a focus for Logo-related research and curriculum development. This project has received the support of the three school districts involved and is presently in the proposal-development stage. Since costs for equipment, research, and curriculum development will be far beyond what can be provided by the school system, the New York Academy of Sciences is seeking support from a number of different groups. It hopes to be able to start with a small number of students this fall.

The Lamplighter School Logo Project

The most ambitious Logo project to date was carried out jointly by the MIT Logo Group, Texas Instruments, and the Lamplighter School, a private school in Dallas, Texas. Lamplighter School has 400 students between the ages of 3 and 9. The school has been provided with 50 Texas Instruments Logo systems that are used throughout the grades. The goal of the project is to establish a setting in which student access to computers would not be a limiting factor and to see what students could learn in such circumstances.

The project is now in its third year. A half-time teacher/coordinator oversees the day-to-day workings of the project and provides individual Logo tutorials for every teacher in the school on a biweekly basis. Computers are in every classroom from the nursery school through fourth grade. Every teacher and child is involved to some extent.

On a recent visit to the school, I was struck by just how comfortable the children are with the computers. Two 4-year-old girls were using a computer to construct geometric designs on a screen with square-shaped sprites. (A sprite is a hardware implementation of a turtle, to allow multiple moving objects on the screen.) Nearby, classmates were engaged in more conventional activities: building with blocks, putting together a puzzle, playing with toy

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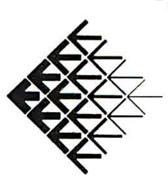
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cars, playing house, and finger painting. Computers for these young students are just another way of exploring their world.

The typing ability of the first and second graders is amazing. The students are already writing simple programs, using the keyboard and the Logo screen editor with great dexterity. One second-grade "hacker" had just invented a procedure that simulated the effect of the reset key, clearing the screen and printing "Welcome to Logo!" He also proudly pointed out, "It doesn't erase your procedures!"

In the third grade, several children were clustered around two computers. One of them had made a "secret" animation program that made a number of sprites move continuously in a dynamically unfolding spiral. Three boys were trying to duplicate the procedure on the adjoining computer. Another child was designing a sprite shape for the center of the screen that would look as if it were emitting the spiraling sprites. Competition, cooperation, communication, problem solving, programming, geometry, and artistry were all happening at once. Meanwhile, the teacher who had introduced the basic idea that all the students were building on was helping another student figure out how to make a sprite move in a circle.

These vignettes should give a sense of the flavor of the school. While some children are occupied with computers, regular school life goes on for others. The class next door may have five computers sitting idle while a geography or reading lesson is being presented much as it would be in any other school. Computers are accepted by the teachers and students as an integral part of the school, but they are not allowed to dominate it.

Some of the anticipated results of the Lamplighter Project have never happened. For example, the students have not used computers for creative writing, despite the availability of a simple screen editor as part of the Logo system. The equipment provided to the school in the first three years of the project has not included printers, which would be needed to make creative writing a realistic activity. Nor has Logo been integrated into as much of the school's curriculum as had been planned. According to Lamplighter's headmistress Pat Mattingly, "The teachers just don't have enough time for curriculum development in addition to all their other duties." With a few minor exceptions, the research studies that were expected to be part of the project have not materialized. Some unique, exciting, and wonderful things have been happening at the Lamplighter School, but except for the school staff, who usually are too busy to write, study, and reflect on the situation, one gets the feeling that "nobody's watching."

Other Interesting Projects

To round out the picture, I want to mention some other schools at which Logo is being used for research and development. The Cotting School for the physically handicapped in Boston has been the site of a series of projects conducted by Dr. Sylvia Weir of MIT. In these projects, Logo has enabled students with cerebral palsy, previously unable to communicate effectively, to begin to realize their intellectual potential. Of all the Logo projects, this has been the most dramatic in demonstrating Logo's effectiveness for students who previously had not been successful in academic settings. It has also made the most significant progress toward the goal of finding objective ways of determining just what students learn as they engage in Logo activities.

Another Logo project aimed at discovering what students are learning is being conducted by the Center for Children and Technology of Bank Street College in New York City. In this project, students in grades three through six have extensive access to Logo. The research is focusing on students learning problem-solving techniques and on social interaction among students as they work on Logo activities—two areas that have been highlighted, but not carefully studied by other projects.

Logo Information Sources

Here is a partial listing of organizations that offer Logo training and information:

1. Logo Training Courses and Workshops:

Austin College, Sherman, TX 75090. Contact Prof. Henry Gorman.

Bank Street College, 610 West 112th St., New York, NY 10025. Contact Karen Scheingold.

Lesley College, 29 Everett St., Cambridge, MA 02138. Contact Nancy Roberts.

Logo: The Learning Center, Logo Computer Systems Inc., 989 Avenue of the Americas, New York, NY 10018. Contact Mike Tempel.

Teachers College, Columbia University, Microcomputer Resource Center, 525 West 120th St., New York, NY 10027. Contact Karen Billings.

Technical Education Research Centers, 8 Eliot St., Cambridge, MA 02138. Contact Robert Tinker.

University of Wisconsin—Oshkosh, Microcomputer Applications Group, Oshkosh, WI 54901. Contact Don Voils.

2. Organizations, Users' Groups, and Newsletters:

Boston Computer Society Logo Users Group, One Center Plaza, Boston, MA 02108.

FOLLK, Friends of LISP/Logo and Kids, 436 Arballo Dr., San Francisco, CA 94132.

Friends of the Turtle, POB 1317, Los Altos, CA 94022.

Logo Times, *included in* 99'er Magazine, *POB 5537, Eugene, OR 97405.*

LOGOPHILE, Logo Special Interest Group, c/o Higginson, Faculty of Education, Queens University, London, Ontario, K7L 3N6 Canada.

Monadnock Area Logo User's Group, c/o Dan and Molly Watt, Gregg Lake Rd., Antrim, NH 03440.

Young People's Logo Association, 1208 Hillsdale Dr., Richardson, TX 75081.

A third interesting Logo school project is not a research project at all. At Lincoln-Sudbury Regional High School in Sudbury, Massachusetts, students learn Logo as the introductory computer programming language. Experiences at Lincoln-Sudbury may show the way to those seeking to use Logo with older students.

Conclusions

I will take the risk of drawing a few general conclusions from these very diverse projects.

Logo can be effective for all students in a school setting. In fact, a regular theme of all the projects cited is the success of students who previously had been unsuccessful in school.

Teacher training is critical. At the very least, teachers need to understand the value of exploratory learning and student interaction. Further, at all sites involving Logo in classrooms, teachers have felt the need for continued support and training. While this need may diminish as teachers become more familiar with computers and Logo, it seems to be a reality for the present.

Teachers and students need resource materials, guidebooks, project suggestions, etc. The more specific the goals, as in the Edinburgh Logo Project or in the physics activities of the Brookline Logo Project, the more specialized and extensive the materials needed.

Student interaction has been a critical and positive element of all classroom-based Logo projects. In each case, students have taken on significant roles as teachers of other students, even as teachers of their own teachers.

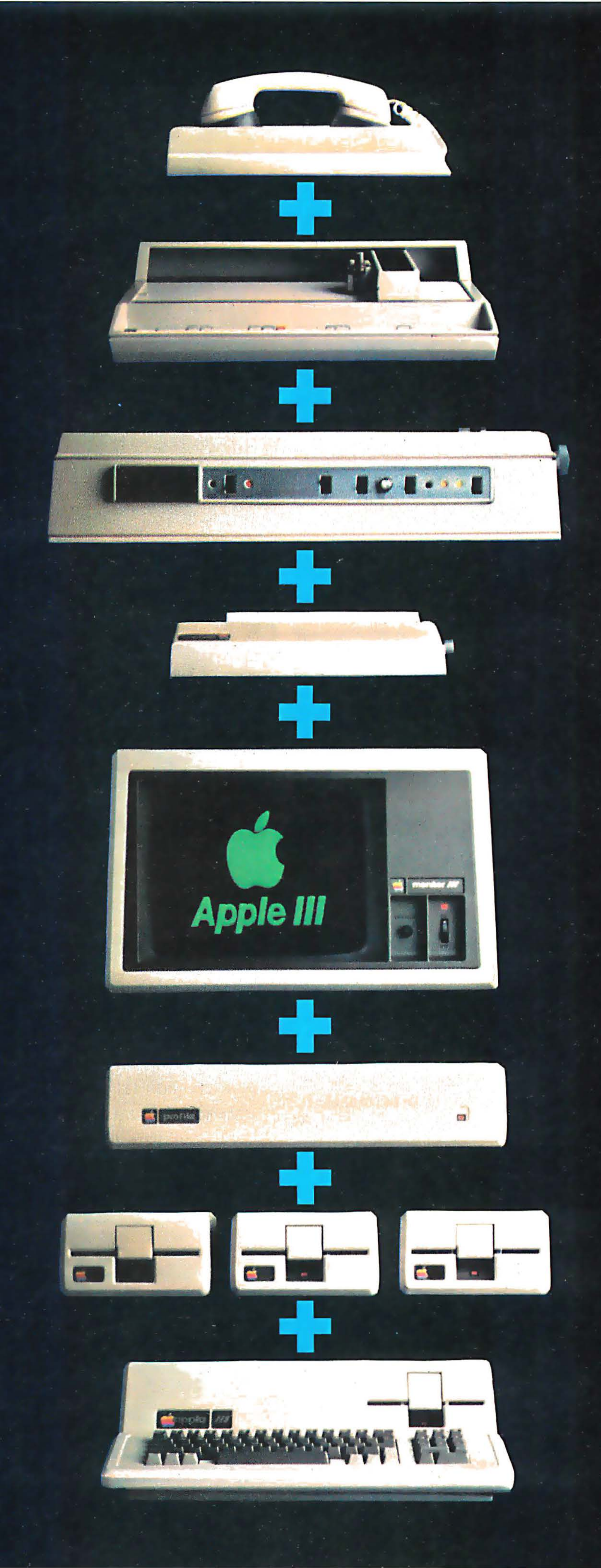
In no case has the "full potential of what might be possible" with Logo been realized. It will probably take a lot of time, and many diverse efforts, before the learning potential of Logo can be fully understood and utilized. Whether the goal is to integrate Logo into existing school subjects or to use

Logo to develop entirely new kinds of learning environments, much work remains to be done.

During the past year, the use of Logo in schools has jumped from less than a dozen sites to hundreds. By the end of the coming year, it may involve thousands of classrooms with tens of thousands of students. As we struggle with the task of integrating new forms of learning into old structures, we should be particularly aware of the opportunity to learn from each other and from the limited, but carefully supported, research and development that have already occurred. ■

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Apple III

Designing Computer-Based Microworlds

Well-designed Logo procedures can help children grasp ideas of intrinsic interest.

R. W. Lawler
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Designing computer applications for education might be called cognitive engineering, for its objective is to shape children's minds. That lofty goal must carry with it a commitment to cognitive science, the study of how knowledge functions and changes in the mind. In light of the profound influence of computers in the schools, designing educational applications without such a commitment would be irresponsible.

I believe that Jean Piaget, the Swiss student of knowledge, formulated the general solution to the problem of how intelligence develops. Although the field of cognitive science has advanced beyond Piaget's innovative theories by revising and extending them, his insights into the nature of learning continue to influence teaching methods. The union of computer microworlds and Piagetian theory is the subject of this article.

Piaget and Education

Central to the work of Piaget is constructivism, the view that the mind incorporates a natural growth of knowledge and that the mind's structure and organization are shaped by interactions among the mind's parts. In *The Science of Education and the Psychology of the Child* (The Viking Press, 1971), Piaget challenges educators to answer two questions: How does instruction affect what is in the mind? and What remains in the mind from the process of instruction long after the time of instruction has passed? In the same work, Piaget disputes both the effectiveness and the ethical correctness of many of the practices of modern education:

> *If we desire to form individuals capable of inventive thought and of helping the society of tomorrow to achieve progress, then it is clear that an education which is an active discovery of reality is superior to one that consists merely in providing the young with ready-made wills to will with and ready-made truths to know with.*

The Dilemma of Instruction

Given Piaget's view that learning is a primary, natural function of the healthy mind, we might consider instruction in any narrow sense unnecessary. Children (and older students of life as well) learn the lessons of the world, effectively if not cheerfully, because reality is the medium through which important objectives are reached. Nevertheless, in certain situations children often rebel against the lessons society says they must learn. Thus the educator's ideal of inspiring and nurturing the love of learning frequently is reduced to motivating indifferent or reluctant students to learn what full functioning in our society requires.

Teachers face a dilemma when they try to move children to do schoolwork that is not intrinsically interesting. Children must be induced to undertake the work either by promise of reward or threat of punishment, and in neither case do they focus on the material to be learned. In this sense the work is construed as a bad thing, an obstacle blocking the way to reward or a reason for punishment. Kurt Lewin explores this dilemma in "The Psychological Situations of Reward and Punishment " (*A Dynamic Theory of Personality: Selected Papers of Kurt Lewin*, McGraw-Hill, 1935). The ideas of Piaget and Lewin have led me to state the central problem of education thus: How can we instruct while respecting the self-constructive character of mind?

Computer-Based Microworlds

In *Mindstorms: Children, Computers, and Powerful Ideas* (Basic Books, 1980) Seymour Papert pro-

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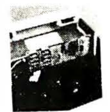
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The Franklin ACE 100 is a personal computer with the power, quality and reliability to meet the most demanding applications of the business professional. It comes complete with 64K of RAM memory which fulfills the demanding memory requirements of VisiCalc and CP/M based programs. The system includes a full upper and lower case keyboard with true shift capability and a numeric pad. The computer generates a full character set to the video screen that displays upper and lower case characters.

The 72 key keyboard includes an alpha lock key which simplifies operation with existing Apple software. The numeric pad cluster includes special keys such as period, plus, minus, greater than (go to) and asterisk (multiply) that are used frequently with VisiCalc.

The Franklin ACE 100 includes a joystick/ game paddle connector, a speaker and eight peripheral connectors. A built-in fan and a 50 watt power supply permit all eight peripheral connectors to be used without power or overheating problems.

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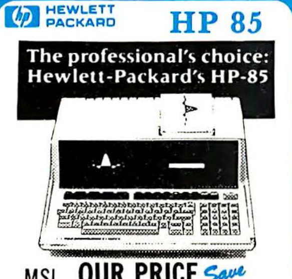


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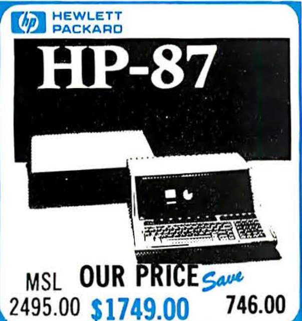
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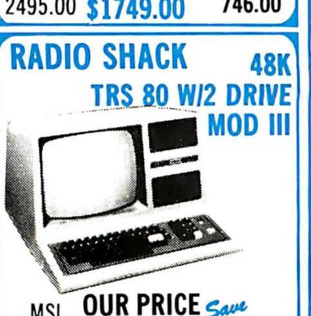
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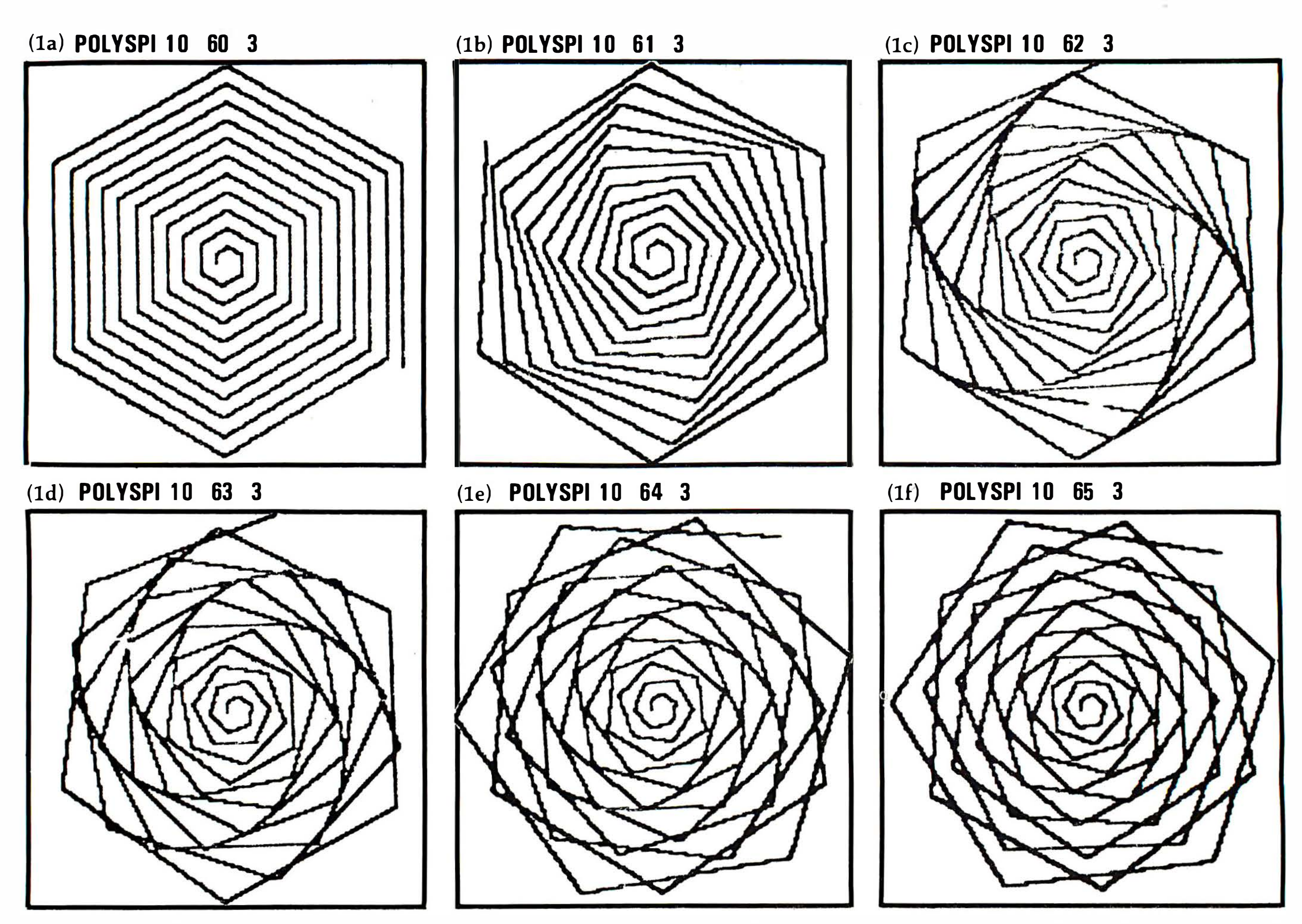
poses computer-based microworlds as a general solution to the problem of motivation. One argument for Papert's proposal runs as follows: learning is often a gradual process of familiarization, of stumbling into puzzlements, and resolving them by proposing and testing simple hypotheses in which new problems resemble others already understood. Microworlds are in essence "task domains" or "problem spaces" designed for virtual, streamlined experience. These worlds encompass objects and processes that we can get to know and understand. The appropriation of the knowledge embodied in those experiences is made possible because the microworld does not focus on "problems" to be done but on "neat phenomena"—phenomena that are inherently interesting to observe and interact with.

With neat phenomena, the challenge to the educator is to formulate so clear a presentation of their elements that even a child can grasp their essence. A well-designed computer microworld embodies the simplest model that an expert can imagine as an acceptable entry point to richer knowledge. If a microworld lacks neat phenomena, it provides no accessible power to justify the child's involvement. We can hardly expect children to learn from such experiences until they are personally engaged in other tasks that make the specific knowledge worthwhile as a tool for achieving some objective. This amounts to an appropriate shifting of accountability from students (who have always been criticized for not liking what they *must* learn) to teachers, those who believe that their values and ideas are worth perpetuating.

Computer-based microworlds help tailor instruction more closely to Piaget's idea of the natural mode of learning. I will illustrate this point by presenting two examples of computer-based microworlds.

The POLYSPI Microworld

POLYSPI (from "polyspiral") is a name for a three-line procedure in the Logo language and for the class of de-



Figures 1a–1f: *Polyspiral designs generated by changing one variable of the three in the* POLYSPI *procedure (shown in listing 1). The procedure's variables are* DISTANCE, ANGLE, *and* CHANGE *(in distance). The procedure draws a design by going forward the specified distance, turning at the specified angle, then increasing the distance by the specified change, going forward for the incremented distance at the specified angle, and so on. In this example, the distance variable and the change in distance are held constant. The angle variable is stepped up by one degree in each design. The strikingly different designs show the power of the concept of stepping variables.*

signs produced by different executions of that procedure. Figures 1a–1f show some examples of POLYSPI designs. The POLYSPI procedure is stated in listing 1. Some of the designs are pretty, mainly because surprising spiral patterns emerge under certain conditions. The general appeal of POLYSPI designs largely accounts for the adoption of turtle graphics as a subsystem of languages such as Smalltalk, Pascal, and even some implementations of PILOT. The variability of the POLYSPI procedure sometimes permits even a beginner to surprise more expert users (as well as himself) with the discovery of beautiful designs.

The procedure in listing 1 and its designs comprise a microworld. The objects of the microworld are all the designs that the procedure can generate, an engaging and extensive domain for exploration. More important, the designs are a class of "neat phenomena" whose generation can be made comprehensible with the following small set of ideas. First, the POLYSPI procedure provides a crisp model of variable separation: the three variables DISTANCE, ANGLE, and CHANGE are each used once, and used differently, in a simple procedure text. Second, the difference in relative potency of the variables (the impact of a unit change on the produced design) is obvious and striking. (ANGLE and then CHANGE are much more potent than DISTANCE.)

The POLYSPI microworld reveals the powerful idea of stepping variables.

The POLYSPI microworld reveals the stepping of variables as a powerful idea. By stepping variables I mean identifying one variable as a dimension of examination and holding all other variables constant while the chosen one is varied incrementally. In short, this microworld provides a clear model of how particular things may be generated through their intersecting dimensions of variation. Piaget judged variable-stepping to be an essential component of formal operational thought. The idea is a powerful one because it is almost universally useful; it is crucial to the process of scientific investigation.

Within the microworlds of turtle geometry, the insights achieved with POLYSPI exploration are easily extended to a related microworld of INSPI designs. The INSPI procedure differs from POLYSPI only in that the



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Listing 1: *The* POLYSPI *procedure, written in Logo. From only three variables—distance, angle, and change in distance—this procedure can generate a remarkable variety of polyspiral designs. The procedure draws by going forward the specified distance, turning at the specified angle, then increasing the distance by the specified change, going forward for the newly incremented distance at the same specified angle, ans so on. Some designs drawn by* POLYSPI *appear in figures 1a–1f.*

```
TO POLYSPI :DISTANCE :ANGLE :CHANGE
FORWARD :DISTANCE
RIGHT :ANGLE
MAKE "DISTANCE :DISTANCE + :CHANGE
POLYSPI :DISTANCE :ANGLE :CHANGE
END
```

change value is applied to the ANGLE variable instead of to the DISTANCE variable. (For a case study of a child's ability to grasp and extend this idea, see my article "Extending a Powerful Idea," in a forthcoming issue of *The Journal of Mathematical Behavior*.)

The BEACH Microworld

The adolescent's initiation to formal thought differs greatly from the preschooler's introduction to reading, yet both learning experiences involve grasping central representations. What the prereader learns in an alphabetic language is a serial symbolic representation for words that signify the names of objects, actions, and so on. Let me here describe a Logo microworld for learning the alphabetic language. This microworld helped my 3-year-old daughter learn to read with minimal direct instruction.

While previous Logo implementations focused on a single, all-important agent—the turtle—TI Logo also has sprites. A sprite is a video-display object that has a location, a heading, and a velocity, but no drawing capability. It may be associated with a shape (which it "carries" and which assumes one of 16 colors). The shapes can be easily defined and changed by the Logo user. There may be a maximum of 25 shapes. The importance of a multitude of easily discriminated objects for early language applications cannot be overestimated. TI Logo has a second graphics system, "tile graphics," that is compatible with the sprite graphics system. The static tiles, which may also assume 16 different colors and exhibit modifiable shapes, provide a suitable "background" for the movements of the dynamic sprites. The result is the opportunity to create scenarios that have many moving objects with different shapes and different colors and a static but vivid backdrop. The BEACH microworld permits the creation of such scenarios, as the scenes in photos 1a and 1b illustrate.

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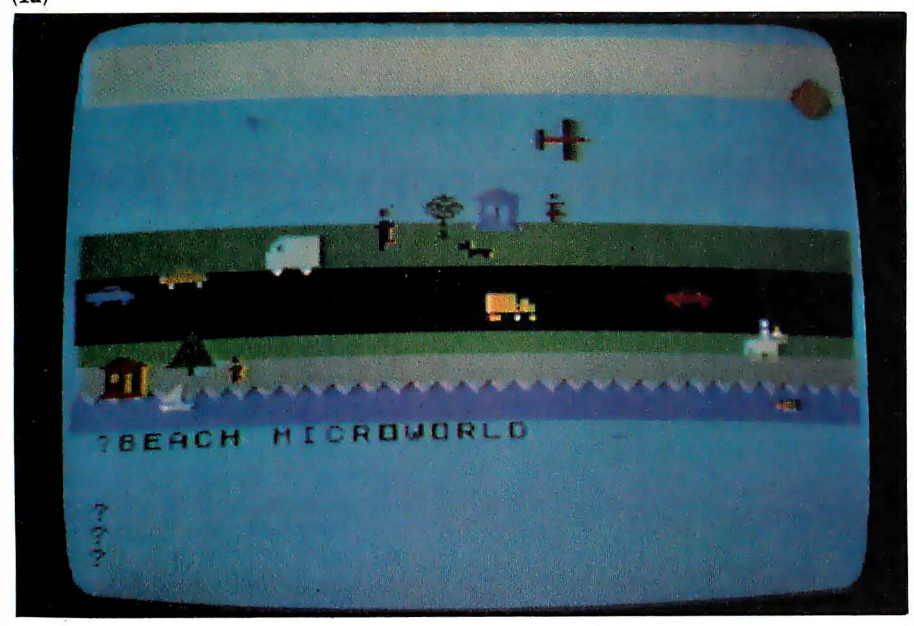
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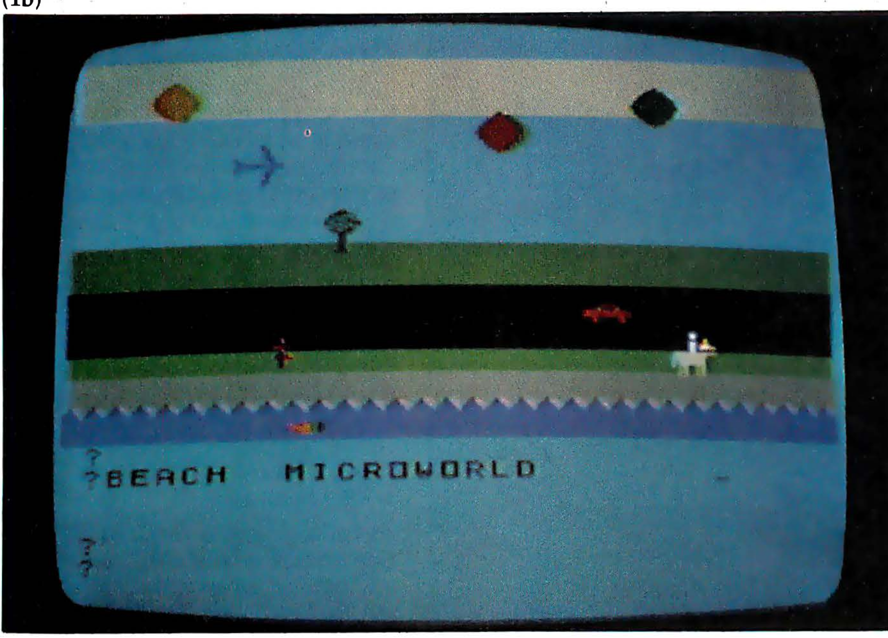
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(1a)



(1b)



Photos 1a–1b: *Two scenes from the* BEACH *microworld. Photo 1a shows a scene with many objects. Photo 1b shows a scene typical of those drawn by a 3-year-old child. The author's daughter learned to read 30 words by exploring the* BEACH *microworld, which the author and his children created using TI Logo with the Texas Instruments 99/4A microcomputer.*

Meaningful Names Ease Learning

Because Logo gives the user great freedom to define and name procedures, appropriate descriptive English words can be used. For example, SUN can be the name of the procedure that creates a yellow ball on the display. The word UP can name the command that increases the value of a sprite's *y* coordinate. Repeated often enough, UP puts the SUN in the sky above the BEACH. Another word, such as SLOW or FAST, can set the SUN in motion. Because new procedures are easily defined, the child, a family member, friend, or teacher could even make the SUN ZOOM if the child wishes. Such flexibility permits the microworld to be tailor-made to suit any child. To the extent that the child participates in defining the objects to be part of the world, their attributes, and the actions they are to perform, the microworld is also constructed *by* the child herself. My 3-year-old, Peggy, her older siblings, and I chose about 20 objects to populate her world, designed and made shapes to represent them, and wrote the procedures to create and manipulate them. The vocabulary of her BEACH world includes the following:

OBJECTS

BEACH, BIRD, BOAT, BOY, CAR, DOG, FISH, GIRL, HOUSE, JET, KID, MAN, MOON, OAK, PINE, PLANE, PONY, STAR, SUN, TRUCK, VAN, WAGON

ACTIONS

UP, DOWN, MOVE, BACKWARD, FAST, FLY, HALT, SAIL, SHOW, SWIM, TURN, WALK, ZAP, ZOOM, PAINT BLACK, PAINT GREEN, etc.

When Peggy began to play with this computer microworld, she did not recognize any words except "by," and she had no idea what that meant. Her ability to discriminate between letters and name them was undependable and idiosyncratic. She began keying words, copying them letter by letter from a set of 4- by 6-inch cards I had made. Soon she began keying her favorite or most-used words from memory, and later she was able to read those individual words in other contexts. Now she deals with the written language one word at a time (as infants begin to speak with specific signification). To handle sentences (other than "paint some-color-name") or begin phonetic decoding of words, she will need more complex microworlds.

For Peggy, the learning of reading and the learning of writing have been synchronized (as speaking and interpreting speech are for the toddler); she learned to read her 30-word vocabulary by learning first to "write," i.e., key the words on the computer terminal. Writing was an essential part of controlling the computer microworld that engaged her. My role as teacher changed from taskmaster to occasional consultant. I would answer questions Peggy brought me after she had tried to work with the constructed reality of the BEACH microworld, and I helped her when she had problems, but I offered her no lessons beyond the rule that words are keyed letter by letter,

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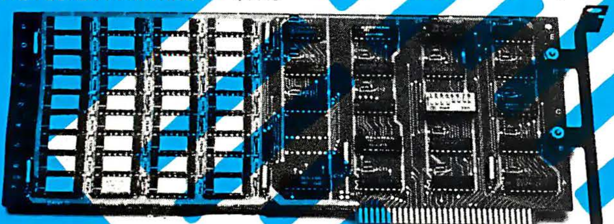
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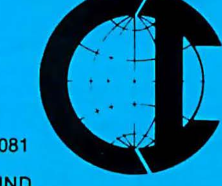
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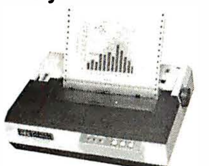
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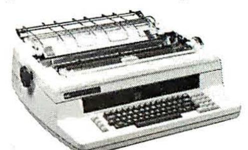


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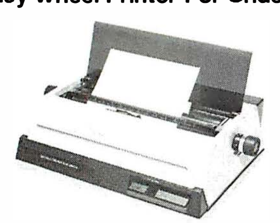




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left to right, and that a specific symbol meant she should press the Enter key.

I make no claim that computer microworlds can teach all reading skills, nor that this specific BEACH world would appeal to other children in different circumstances. I do, however, see the BEACH microworld as a prototype of the various worlds that others may fashion for small children.

Design Heuristics: Powerful Ideas

A computer microworld should be constructed around a powerful idea, one worth the instructor's time to develop or the student's time to explore. Who decides if an idea is sufficiently powerful? You do, at first, when you design a microworld. Next, the students determine the worth of the microworld as they incorporate the idea into their minds or reject it.

If you need a little guidance when you design a computer-based microworld, Papert (in *Mindstorms*) offers four criteria for powerful ideas: they should be simple, general, useful, and syntonic. The idea behind a microworld must be formulated as simply as possible; an idea can be powerful only when understood. Even if an idea is embodied in a specific microworld, it will not be useful through extension unless it is general.

Reality dictates the candidates for powerful ideas. Society also declares what ideas are important: if you can't read, for example, a technological society relegates you to subhuman status. But it is your own mind, more than any advice, that can tell you what ideas are powerful. Your own insights enable you to integrate important experiences. An idea is powerful, then, if it gives form to your understanding of life. It follows that you cannot inspire others with an idea unless it has first inspired you.

Interconnection of Knowledge

What Papert labels the "syntonic" characteristic focuses on how an idea assumes power within the mind of an individual. An idea is powerful for a person if it relates and unifies knowledge gained in diverse experiences. An idea gains power if it can be reduced to a concrete model that serves as a metaphor for the interpretation of subsequent problems. Such a model helps explain which aspects of new problems must be considered, which may be neglected, and which anomalies must be explained away on a basis of local evidence. Models prove more or less powerful depending on the individual's interests and experiences.

The most essential characteristic of powerful ideas is their relation to the individual's previous knowledge. You can tell students that one situation resembles another, but recognition of such comparisons is more powerful if it is the students' own discovery. They will make the connections between the structures of one idea and another at a level of detail appropriate to their specific prior knowledge and feelings. This internalization is the basis of an idea's power for the individual.

An analogy may help here. If you solder a connection at too low a temperature, you can get mechanical binding but undependable electrical contact. Ideas imposed by instruction are like badly soldered joints. Only the individual has the power to fuse connections between new ideas and his or her own most personal thoughts and feelings. These connections alone can make an idea an important part of how the person sees the world and behaves in it.

Paradoxically, an excellent way to harness the students' understanding for engagement with ideas is to liberate their expressiveness. Because Logo is a vehicle for free exploration, knowledge built from Logo is syntonic, appropriate to the person, and experienced as an authentic, intimate part of the self. Such is the power of an approach to learning that frees the individual to create within a social context that makes our culture's most powerful ideas accessible.

I/O and Applications Design

An application design negotiates between a specific objective and the potential of the equipment. Computers are general-purpose symbol manipulators, so they can deal

abstractly with an idea. What any computer system can do in an interesting way, however, depends on its input/output (I/O) devices. Look for something special about a machine's I/O to suggest the kinds of neat phenomena the system could exhibit. Consider these examples from previously implemented Logo systems:

- The accessibility of the robot floor-turtle world to a child's physical intervention can lead even a small child into simulating the turtle's actions and into debugging procedures (after fixing a procedure "manually," a child can become more engaged in fixing it symbolically).
- Turtle graphics—whose appeal depends largely on the emergence of patterns from simple procedures that command the drawing of many lines—came into its own only with the general availability of bit-map-based displays.
- Logo on the GTI-3500 had a significant potential for engineering and physics simulations because a hardware-implemented "spin" primitive extended the forward and right primitives of "classical" Logo.
- The TI 99/4A joins together a general-purpose microprocessor (where TI Logo is implemented) with a special-purpose graphics processor that manipulates the sprites that give TI Logo its most striking effects.

As increasingly powerful microprocessors become affordable, the special quality of each will bring new potential for creating engaging microworlds. More powerful microprocessors and graphics slave processors may, for example, bring molecule modeling within reach. Local networks of small machines may permit group simulation of economic and political situations (as in games) that are now too abstract, rule-driven, and theoretical to interest many young people. There will continue to be opportunities for creating microworlds around the most powerful ideas of contemporary science and technology.

Objects in Microworlds

Logo procedures can serve as a bridge between less precise and more formal systems. The commands of Logo are designed to communicate with a computer and its output devices, but the extension of Logo through procedures whose names are natural-language words can make the objects and actions more comprehensible. This ability to be extended is a key feature for young children.

But Logo is only a quasi-natural language; a Logo procedure must run on a machine. Further, the objects of a Logo microworld are formal; they can be completely defined by a specification of their state variables. One of the simplest of these objects is the Logo screen turtle. Once you have specified the turtle's location, heading, and pen position, there is no more to say about it. The operations of a microworld are also completely specifiable in terms of the effects they have on state variables. The RIGHT and LEFT commands, for example, modify the heading of the turtle but do not affect its location. Given the object orientation of Logo and the ease of specifying the interaction of state-change operations with state variables, a first criterion for the quality of any Logo implementation (an application microworld or the interpreter itself) is the clear presentation of the state variables to someone using the system. Two examples of representation inadequacies in TI Logo can clarify the point: although the heading of a sprite is a significant state variable, it cannot be determined by inspecting the object's appearance (the shape carried by the sprite) when its velocity is zero; it is impossible to determine visually which sprite is the "current" object, i.e., the one or ones that will respond to the next Logo command. Ideally, the equivalent of a SHOWTURTLE/HIDETURTLE set of commands would show which is the active sprite. Whatever the limitations of a specific Logo implementation, anyone who designs a computer-based microworld should strive to represent all the state vari-

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ables in a visible, obvious way. Doing so enhances the comprehensibility of the ideas embodied in the objects and their manipulations.

Comments on a New Microworld

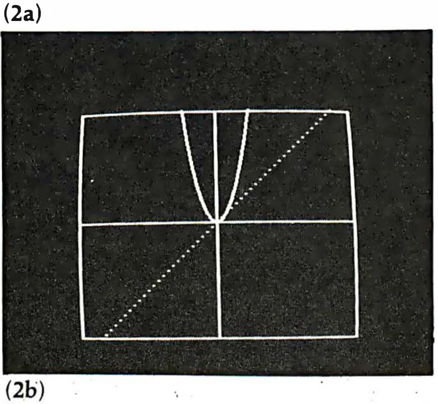
One of the objectives of Logo is to put power in the hands of beginning users. Even powerful ideas usually come from striving to reach a simple, down-to-earth objective. To demystify designing a microworld, I would like to present a few comments on some work in process. I wanted to develop an effective way to present some ideas of algebra to a 12-year-old. I remembered a casual comment of a former MIT Logo colleague, Andy diSessa, that one of the most powerful ideas accessible through Logo was embodied in "procedures that output." At the time, I was mystified, even though Andy had explained that his comment was based on the fact that such a procedure was equivalent to a mathematical function. *That* observation came back to me. Algebra is about mathematical functions. Although I couldn't fully appreciate Andy's comment, it focused my attention on a personally comprehensible way of expressing mathematical functions in Logo.

Common mathematical functions assign the value of one variable (call it y) to the value of some expression based on another variable (call it x). Assigning values is just what the MAKE command does. If a superprocedure controlled assigning to y the value of an x-based expression for the domain of possible values of x, it would generate any function expressible in the Logo language. When given two inputs (x,y), the DOT primitive of Apple Logo draws a dot at the screen location of those coordinate values. If the value of x is incremented across the domain of possible x-coordinate values, and y is specified in terms of the value of x, DOT can be used to plot discrete sketches of mathematical functions. A second method of drawing functions is possible. If those "dotted" locations are used as the position coordinates of a SETTURTLE (SETPOSITION) command, the screen turtle will draw a line-segment approximation to a mathematical function. These are the ideas around which the PLOTTING microworld is constructed. Photos 2a and 2b show examples from the PLOTTING microworld.

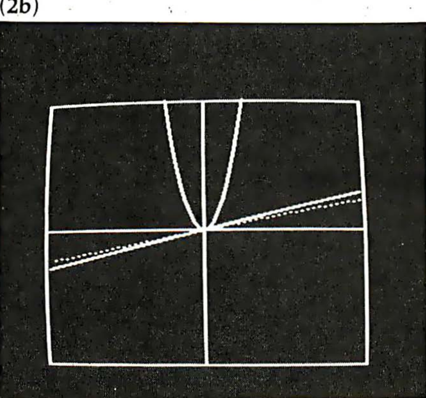
How can a person go from common experiences to a new idea by doing something only slightly unusual—but with that small difference providing access to a range of significant phenomena? Think about what kinds of experiences younger students might have had that could support learning about mathematical functions. Any child who uses Logo for a while learns to define specific variable values using the MAKE primitive; for example:

```
MAKE "MY.NAME "BOB
MAKE "MY.AGE 42
```

(2a)



(2b)



Photos 2a, 2b: *Two examples of the* PLOTTING *microworld. Photo 2a shows the contrast between the straight-line plot of* $y=x$ *and the parabolic plot of* $y=.2x^2$. *Photo 2b contrasts the same parabolic plot with a plot of* $y=.25x$ *(segmented line), an attempt to fit the slope (heavy line) of the parabola at a point. See listing 2 on page 158 for the* DOTPLOT *procedure from the* PLOTTING *microworld.*

The minimal significant complication possible in the specification of a variable is to make its value depend on something else, such as keyboard input. It is common for beginners to write routines such as the greeting below for inclusion in some more ambitious program:

```
TO GREET
PRINT [WHAT'S YOUR NAME ?]
MAKE "WHO READWORD
  ;accept keyboard input
PRINT (SENTENCE
  [GLAD TO MEET YOU,] :WHO)
END
```

We can start with nonarithmetic examples of variables as functions of other variables. They can be simple or complex. Graphs of equations can be viewed as another, more specific form of a familiar kind of relation—a new representation for a familiar idea. The algebraic formulas with which we usually associate the graphs of equations are seen as another description of a correspondence relation, a description that is specific and limited, but very powerful.

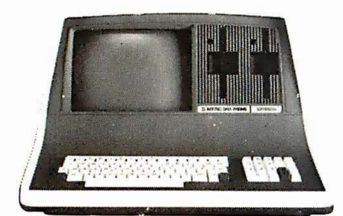
Making clear the connection between concrete uses of programming variables and mathematical functions is one justification of a PLOTTING microworld. This idea is one I judge to be powerful. The programming needed to make a Logo PLOTTING subsystem is nearly trivial (see listing 2), but that is precisely the virtue of a powerful language: its expressiveness makes ideas and functions stand clear of accidental complications.

Extending the PLOTTING World

If we look beyond the simple plotting of functions, the intellectual extensions of such a microworld can be simple and striking. Consider these two possibilities. First, when the domain of x is specified with beginning, end, and increment or step-size (to control the grain of the plotted function), the slogan through which continuity is often expressed becomes an almost obvious consequence of the "dotted" representation: "you give me an *epsilon*, and I can give you a *delta* such that whenever the difference between successive values of x

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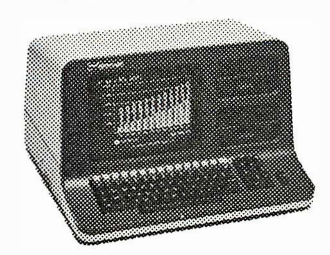
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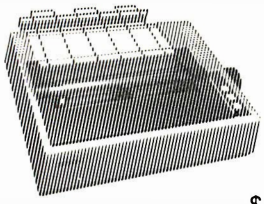
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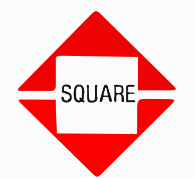
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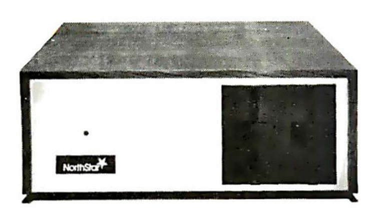
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Listing 2: *The* DOTPLOT *procedure, written in Logo. The procedure plots y as a function of x for values of x incremented by* CHANGE. *Resulting plots appear in photos 2a–2b.*

```
TO DOT.PLOT :CHANGE
MAKE "X -135
PRINT [MAKE "Y A FUNCTION OF :X]
MAKE "FUNCTION READLIST
LABEL "AGAIN IF :X > 135 [STOP]
RUN :FUNCTION
IF NOT OR :Y > 119 :Y < -119 [DOT SE :X :Y]
MAKE "X :X + :CHANGE
GO "AGAIN
END
```

Listing 3: *The* LJ1 *procedure, written in Logo. Using the variables* COEFF1, COEFF2, *and* CHANGE, *the procedure draws Lissajous figures like those shown in photos 3b, 3c, and 3e.*

```
TO LJ1 :COEFF1 :COEFF2 :CHANGE
MAKE "ANGLE 0
MAKE "FUN1 (SENTENCE [MAKE "X 100 * SIN :COEFF1 * :ANGLE])
MAKE "FUN2 (SENTENCE [MAKE "Y 100 * COS :COEFF2 * :ANGLE])
PENUP RUN :FUN1 RUN :FUN2 SETPOS (SENTENCE :X :Y) PENDOWN
LABEL "AGAIN MAKE "ANGLE :ANGLE + :CHANGE
RUN :FUN1 RUN :FUN2
SETPOS (SENTENCE :X :Y)
GO "AGAIN
END
```

is less than *delta*, the difference between successive values of *y* will be less than *epsilon*." Second, consider the implications for understanding the differential calculus. When plotting the value of a function, it is simple to save the value of the prior point-couple and calculate the slope of the function. This is an empirical form of differentiation. A microworld of plotting tools (whose activities could include plotting functions, the empirical derivation of slopes of those functions, and curve fitting—with the plotting tools—to those empirically derived slopes) could provide a body of practical experience about the relations between functions and their slopes. This experience, for which differential calculus will later provide a theory, will make the calculus easier to appreciate and assimilate.

These ideas may interest a math teacher or a psychologist, but would any child be interested in plotting mathematical functions? Are there any accessible neat phenomena? This is the most important final question the creator of every microworld must face. The concrete appeal of this microworld must be the creation of appealing (and possibly puzzling) graphic designs. The beauty of turtle-geometry designs derives from the use of repetition and variables in simple procedures. This observation suggests that we look at repeating functions such as those produced by the sine and cosine primitives. Photos 3a–3f show six designs made from combinations of sine and cosine functions. These designs, generically known as Lissajous figures, are my candidates for neat phenomena of the PLOTTING microworld. [**Editor's Note:** *Named for French physicist Jules Lissajous, each of these figures consists of the series of plane curves traced by an object that executes two mutually perpendicular harmonic motions. . . .* **P.L.**] The method of the procedure shown in listing 3 is to calculate a screen location with *x* as a sine function of an angle value and *y* as a cosine function of the same angle. The design is made when the turtle draws a line as it moves from one calculated location to the next one. The procedure is stopped manually.

Lissajous figures are similar to POLYSPI designs in general character because they are made of line segments that show natural classes or families of shapes and occasionally emerge as surprisingly beautiful. Like INSPI designs, they are somewhat mysterious to those who think more concretely than formally. Are they



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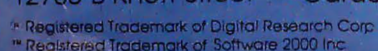
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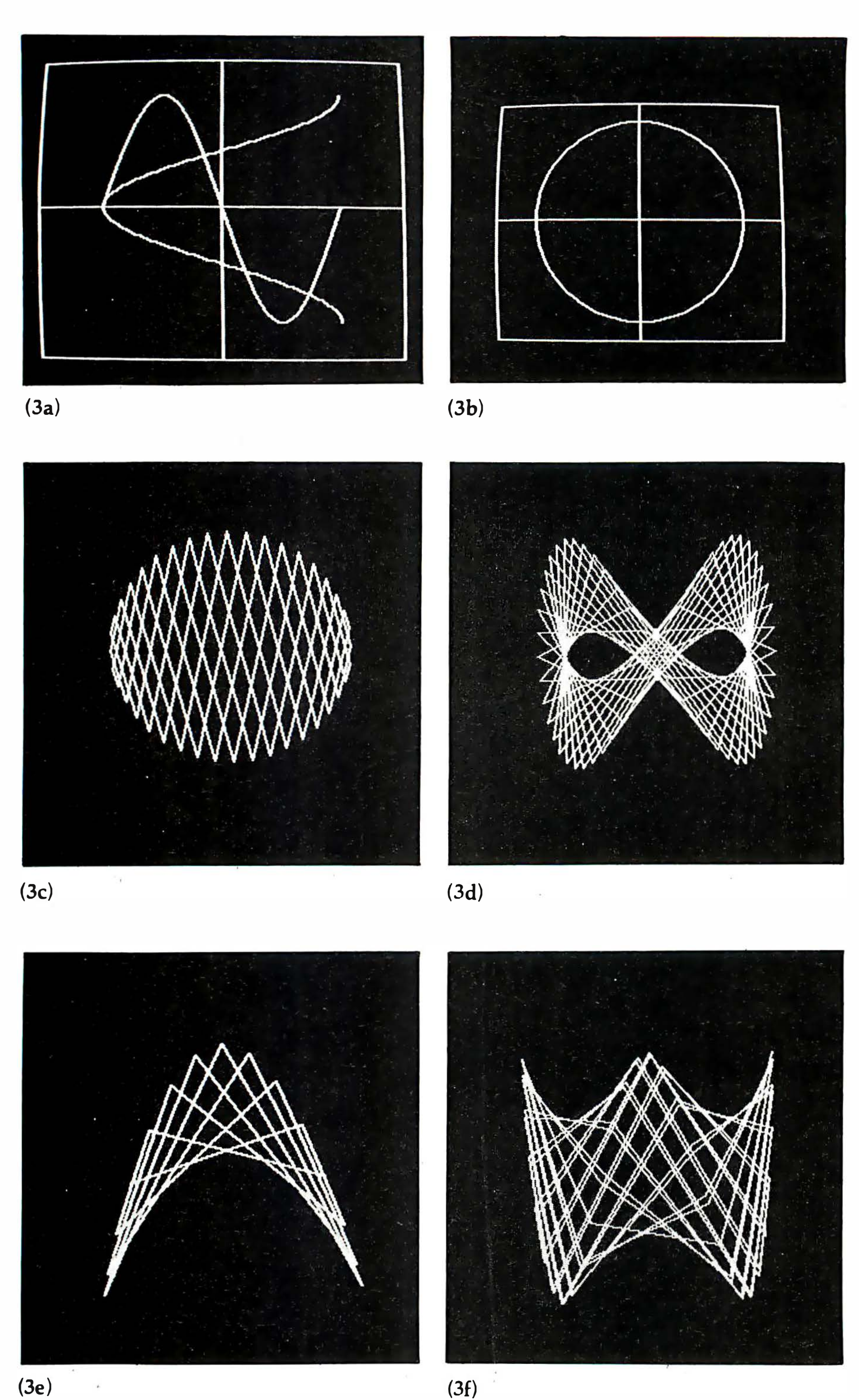
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(3a) (3b) (3c) (3d) (3e) (3f)

Photos 3a–3f: *Six more designs from the* PLOTTING *microworld. The author regards designs made from sine and cosine functions as neat phenomena; i.e., phenomena inherently interesting to observe or interact with. In each design, a procedure calculates a screen location with x as a sine function of an angle value, and y as a cosine function of the same angle. The turtle draws a line by moving from one calculated location to the next.*

Photo 3a shows a plot of y = sin x and x = cos y. The designs in photos 3b, 3c, and 3e were plotted using the LJ1 *procedure shown in listing 3, with the following respective sets of values for the three variables* (COEFF1, COEFF2, *and* CHANGE) *in the procedure: 1, 1, 1; 77, 23, 9; 1, 2, 84. The design in photo 3d was plotted by a similar procedure that plots cosine against sine, using the values 13, 26, 6. Photo 3f resulted from another similar procedure that plots cosine against cosine, in this case using the values 7, 28, 43.*

"neat" enough? Will their appeal be universal? Such questions are clearly impossible for me to answer. If this microworld is of limited interest, perhaps you will have a better idea. More power to you!

The Challenge to Educators

If Piaget's vision that education should involve active discovery of reality is correct and Papert is right in saying that computer-based microworlds provide a solution to the central problem of education, the challenge of education will be more technical in nature than theoretical or ideological.

Clearly, the computer revolution *is* having a significant impact on education. But that revolution is only worthwhile if it liberates people, which it can by offering educators two remarkable opportunities: with computer technology, teachers will be able to help children expand their love of learning; in turn, teachers will achieve a kind of professional status long denied them. Teachers, programmers, and other microworld designers will be the architects of inner space, proposing ideas and creating tools that will enrich our minds. ■

Acknowledgments

Many people in the extended Logo community have contributed to the ideas of this paper. Seymour Papert's influence is central and obvious. Conversations with people who have worked for or visited Logo Computer Systems in Boston and New York have inspired observations or explanations. Dan Watt's editorial comments have been helpful. The article was revised for publication while the author was a consultant to Le Centre Mondial L'Informatique et Resources Humaine. Thanks to Guy Montpetit for use of the text processor and to the Spencer Foundation for support during a period when these ideas were developing.

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Why Logo?

Logo is designed to encourage development of problem-solving skills.

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Logo is a language for learning. That sentence, one of the slogans of the Logo movement, contains a subtle pun. The obvious meaning is that Logo is a language for learning programming; it is designed to make computer programming as easy as possible to understand. But Logo is also a language for learning in general. To put it somewhat grandly, Logo is a language for learning how to think. Its history is rooted strongly in computer-science research, especially in artificial intelligence. But it is also rooted in Jean Piaget's research into how children develop thinking skills.

In a certain sense, all programming languages are the same. That is, if you can solve a problem in one language, you can solve it in another—somehow. What makes languages different is that some types of problems are easier to solve in one language than in another. Language designers decide what kinds of problems their language should do best. They then make design choices in terms of those goals.

About the Author

Brian Harvey is director of the computer center at Lincoln-Sudbury Regional High School, 390 Lincoln Rd., Sudbury, MA 01776. He modified Logo for its PDP-11 minicomputer.

Logo as a Programming Language

Let's postpone for a while the broader educational issues. First, we'll consider Logo simply as a programming language. How is it similar to other languages; how is it different? Syntactic details aside, there are several substantial points of language design through which Logo can be compared to other languages.

Logo is procedural. A programming project in Logo is not written as one huge program. Instead, the problem is divided into small pieces, and a separate *procedure* is written for each piece. In this respect, Logo is like most modern languages. Pascal, APL, LISP, C, and even FORTRAN permit the division of a program into independent procedures. Among the popular general-purpose languages, only BASIC lacks this capability. (The sample Logo programs in this article are written in Apple Logo, a dialect written by Logo Computer Systems Inc. Other versions of Logo will be slightly different in details.)

Consider the Logo program in listing 1a. Even if you don't know anything about Logo, it's probably obvious what this pair of procedures does. Compare it to the BASIC version in listing 1b.

The GOSUB construct in BASIC is weaker than a true procedure capability in several ways. For one thing, the BASIC subroutine is not an independent program; if line 100 were omitted, the program would "fall into" the subroutine. More important, there is no concept in BASIC of inputs to procedures, like QUESTION and ANSWER in the Logo program. Instead, extra statements must be used to assign values to the variables Q$ and A$, explicitly.

This explicit assignment is not simply an inconvenience. It means that the main part of the program has to "know" about the inner workings of the subroutine. In the Logo version, the procedure named QUIZ knows only that the procedure QA has two inputs, a question and an answer. If QA were modified to use different names for the variables, QUIZ would still work. Similarly, although this particular example doesn't show it, Logo procedures can have an *output* that is communicated to the calling procedure. (The DEF statement in BASIC provides a limited version of procedures with outputs; the limitations are that the inputs and outputs must be numbers, and the definition must be a single line without conditional branching.)

Logo is interactive. Like BASIC, but unlike Pascal, Logo lets you type in a command to be carried out *right away*. It's also quick and easy to change one line of a program. Other interactive languages are LISP and

Listing 1: *Comparison of Logo and BASIC. Each program asks the same set of three questions and compares the user's response to the author's answer. In the BASIC version (listing 1b), the "questioning" subroutine (lines 1000–1110) is not an independent program. In the Logo version (listing 1a), the procedure QA could stand alone, and might conceivably be used by other programs.*

(1a)

```
TO QUIZ
QA [WHAT'S THE BEST MOVIE EVER?] [CASABLANCA]
QA [HOW MUCH IS 2 + 2?] [5]
QA [WHO WROTE "COMPULSORY MISEDUCATION"?] [PAUL GOODMAN]
END

TO QA :QUESTION :ANSWER
TYPE :QUESTION
TEST EQUALP :ANSWER READLIST
IFTRUE [PRINT [YOU'RE RIGHT!]]
IFFALSE [PRINT SENTENCE [NO, DUMMY, IT'S] :ANSWER]
END
```

(1b)

```
10 Q$ = "WHAT'S THE BEST MOVIE EVER?"
20 A$ = "CASABLANCA"
30 GOSUB 1000
40 Q$ = "HOW MUCH IS 2+2?"
50 A$ = "5"
60 GOSUB 1000
70 Q$ = "WHO WROTE 'COMPULSORY MISEDUCATION'?"
80 A$ = "PAUL GOODMAN"
90 GOSUB 1000
100 GOTO 9999
1000 PRINT Q$;
1010 INPUT R$
1020 IF R$ = A$ THEN GOTO 1100
1030 PRINT "NO, DUMMY, IT'S ";A$
1040 RETURN
1100 PRINT "YOU'RE RIGHT!"
1110 RETURN
9999 END.
```

APL; other noninteractive languages are C and FORTRAN.

Whether or not a language is interactive has an effect on its efficiency. In brief, program development is generally faster with an interactive language, but already-written programs generally run faster in a language that is not interactive. The difference has to do with the mechanism by which the computer "understands" your program.

Every computer is built to understand one particular language. This machine language is different for each type of computer. Since machine-language instructions are represented as numbers, they're not easy for people to read. For example, the number 23147265 might mean "add the number in memory location number 147 to the number in memory location 265." Programs written in a high-level language, including Logo and the other languages mentioned here, must be translated into machine language before the computer can carry them out. This translation is done by another computer program that comes in one of two flavors: compiler or interpreter.

A Pascal compiler, for example, takes a program written in Pascal and translates (compiles) it into the machine language of whatever computer you're using. The translated program is permanently saved as machine language (probably as a file on your floppy disk). Thereafter, the machine-language program can be executed directly. The compiling process takes a long time. But once it's finished, running the compiled program is very fast because it need never be compiled again.

A Logo interpreter, on the other hand, does not create a permanent machine-language version of your program. Instead, each Logo statement is translated and executed every time the statement is supposed to be executed. The interpreter does not produce a machine-language representation of your program, but simply carries out the machine-language steps itself. If a Logo statement is to be executed six times, it's translated six times. (Actually, some interpreters, including Apple Logo, save a partial translation of each procedure, so that the second execution is somewhat faster than the first; this process is too complicated to explain in this article.)

Interpreted languages can be interactive. Suppose you want to find the value of 2+2 in Pascal. First, you must use the text-editor part of your Pascal system to write a disk file containing a Pascal program. Then, you run the Pascal compiler, which will translate the program into machine language. Finally, you run the compiled program and your computer types out 4. In an interpreted language like Logo, you can simply type PRINT 2 + 2 to see the same result.

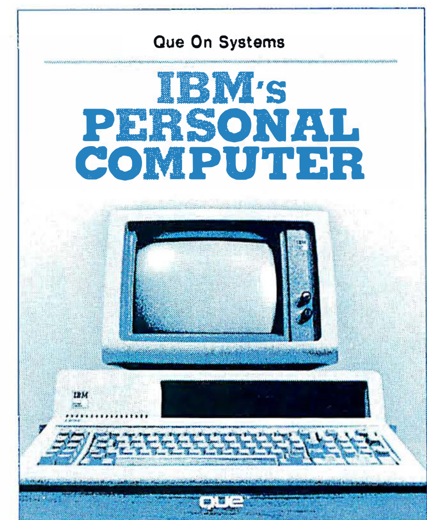
The situation in which interaction is most important is program development. If you are writing a complicated program, it probably won't work right the first time you try it. You'll have to try it, see what goes wrong, change the program, and try again. In order to see what went wrong, you'd like to be able to use interactive debugging. (You stop the program where the error happens and type in commands to examine the values of variables at that moment.) This debugging cycle may be repeated many times before the program finally works completely. Even though a compiler might make the program run faster, an interpreter is likely to make the entire debugging process faster because it's so much easier to find and fix your mistakes. It's only after the program works, and you want to use it every day without modification, that the compiled version is really faster.

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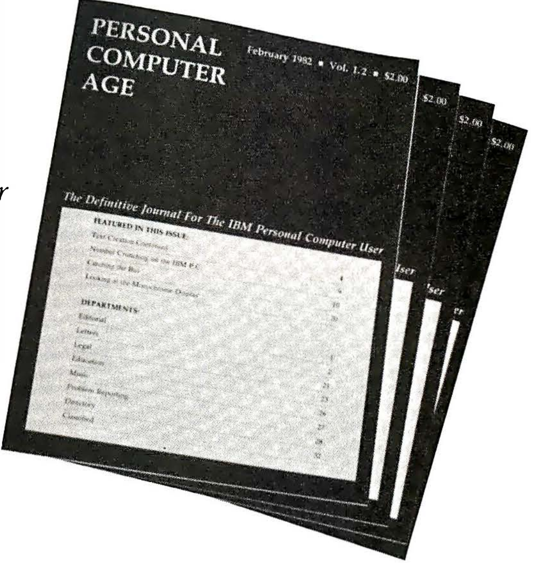
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The flexibility and ease of use of an interactive language is particularly valuable in an educational setting. For a student of programming, there often is no production phase—the program is of interest only as long as it doesn't work. When it does work, the student goes on to the next problem. In that sort of environment, the speed advantage of the compiler never materializes. In a business environment, on the other hand, the actual production use of a program is likely to be more important, which makes a compiler more desirable.

Some languages use mixed schemes. BASIC (normally an interpreted language) has compilers that allow the user to give up interaction for efficiency. Some LISP compilers can coexist with interpreters, so that some procedures can be compiled while others are being debugged interactively. Some versions of Pascal are compiled into an intermediate language called p-code, which is then interpreted. FORTH uses a similar system of partial compilation, but the compiler is part of the run-time environment, so single statements can be compiled and run interactively.

Logo is recursive. In a procedural language, one procedure can use another procedure as a *subprocedure* to do part of its work. A language is *recursive* if a procedure can be a subprocedure of itself.

All modern procedural languages allow recursion. Among widely used languages, only FORTRAN allows procedures but not recursion. (BASIC, as was mentioned earlier, has neither.) It may seem as though recursion isn't too important. Why should it be any different from any other use of subprocedures? It's hard to explain in a simple way why recursion is important. The idea behind recursion, though, has profound mathematical importance. By allowing a complicated problem to be described in terms of simpler versions of itself, recursion allows very large problems to be stated in a very compact form.

A well-known example of a problem best solved using recursion is the Tower of Hanoi puzzle. This puzzle



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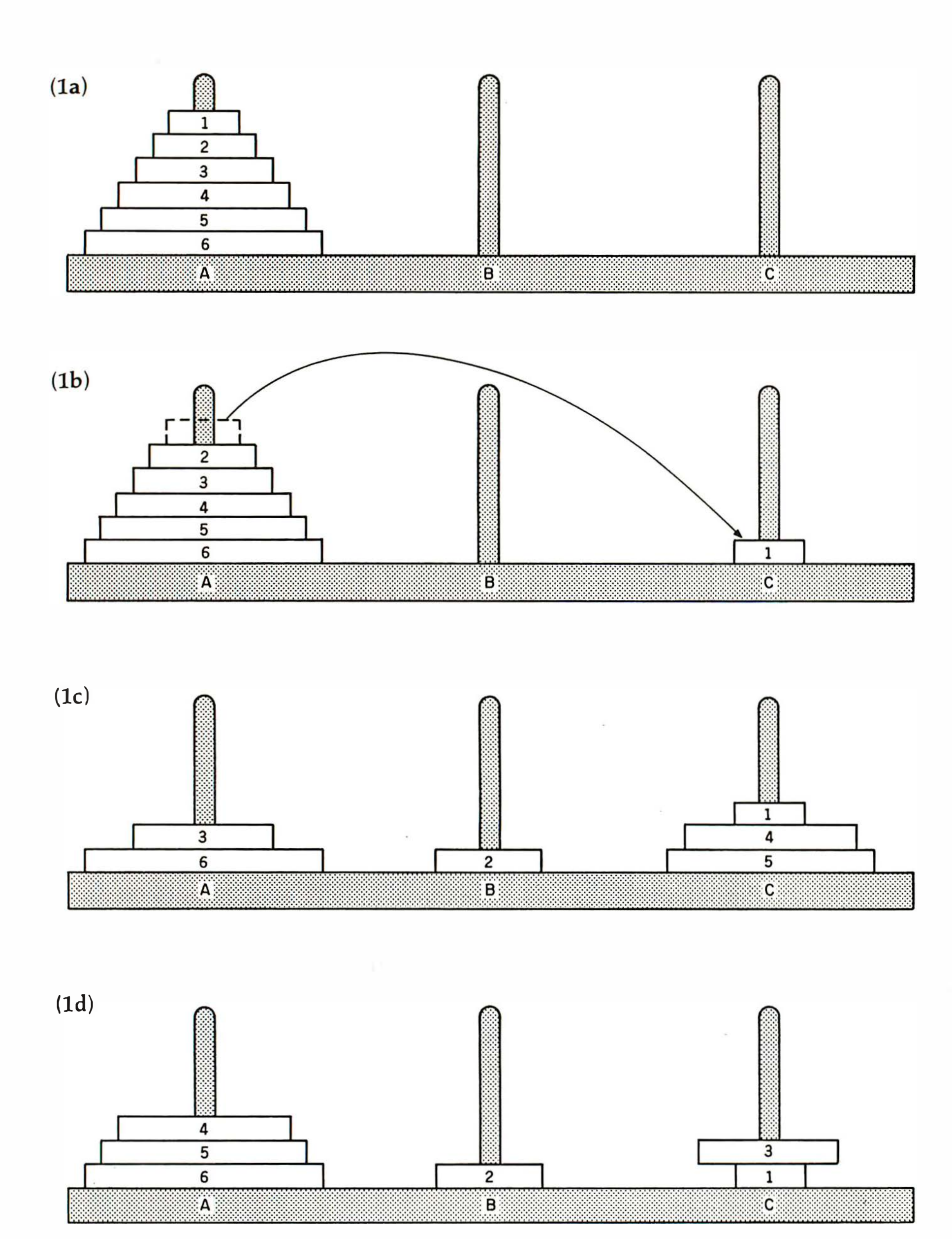


Figure 1: *Typical moves in the Tower of Hanoi puzzle. Figure 1a shows the initial position, figure 1b the first move, and figure 1c the position after several moves. Figure 1d shows an illegal situation with a larger disk on a smaller one.*

has a number of different-size disks piled initially on one of three pegs, with the smallest at the top. The problem is to move the disks onto a different peg, moving one disk at a time and never moving a disk onto a smaller disk (see figure 1).

To solve this problem, first notice that it's very easy with only two disks (see figure 2a). It's easy to see that we have to get disk 2 onto peg B somehow. To do that, we have to get disk 1 out of the way. Therefore, move disk 1 to peg C, disk 2 to peg B, and disk 1 to peg B.

Now suppose there are six disks (see figure 2b). Again, we have to begin by getting disk 6, the largest one, from peg A to peg B. But now there are five disks in the way, not just one. This provides us with a subproblem: move five disks from peg A to peg C. But this is exactly the Tower of Hanoi puzzle itself with five disks instead of six! The subproblem is a simpler version of the main problem. This calls for the recursive solution shown in listing 2.

In working through this program, bear in mind that each use of the HANOI procedure has its own, private variables; the value of NUMBER, for example, remains constant throughout any particular use of the procedure, even though there is another use of HANOI with a different value for NUMBER in the middle.

In addition to Logo, many other languages allow recursion (these include Pascal, C, LISP, and APL). The style of Logo, however, encourages the use of recursion more than some other languages. C and Pascal allow recursion but encourage iteration. (Iteration means telling the computer to execute something repeatedly. The FOR. . .NEXT construct in BASIC is an example.) Logo is the other way around: iteration is possible, but recursion is preferred. For many purposes, neither approach is clearly right. Iteration is somewhat simpler for the situations in which it works at all; in some cases like the Tower of Hanoi puzzle, however, nothing but recursion will do.

Until recently, iteration was much more efficient than recursion, both in speed and in the use of memory. A major advance in recent implementations of Logo, including the versions available for the Apple II and the Texas Instruments TI-99/4A microcomputers, is that *tail recursion* is recognized by the interpreter and treated as if it were written as iteration. Tail recursion is the situation in which the recursive use of a procedure is the last thing done in the procedure. In general, it is only tail-recursive programs that could just as easily be done iteratively. The HANOI procedure, for example, is not tail recursive because two recursive procedure calls are in it, only one of which is at the end.

Logo has list processing. Every major programming language has some way to group several pieces of information (numbers, for example) into one large unit. In FORTRAN and BASIC, this mechanism is the array. In Pascal and C, arrays are also used, along with a more complicated grouping called a record in Pascal or a structure in C. In Logo, the main grouping mechanism is called the *list*.

Lists and arrays have two major differences. First, arrays have a fixed

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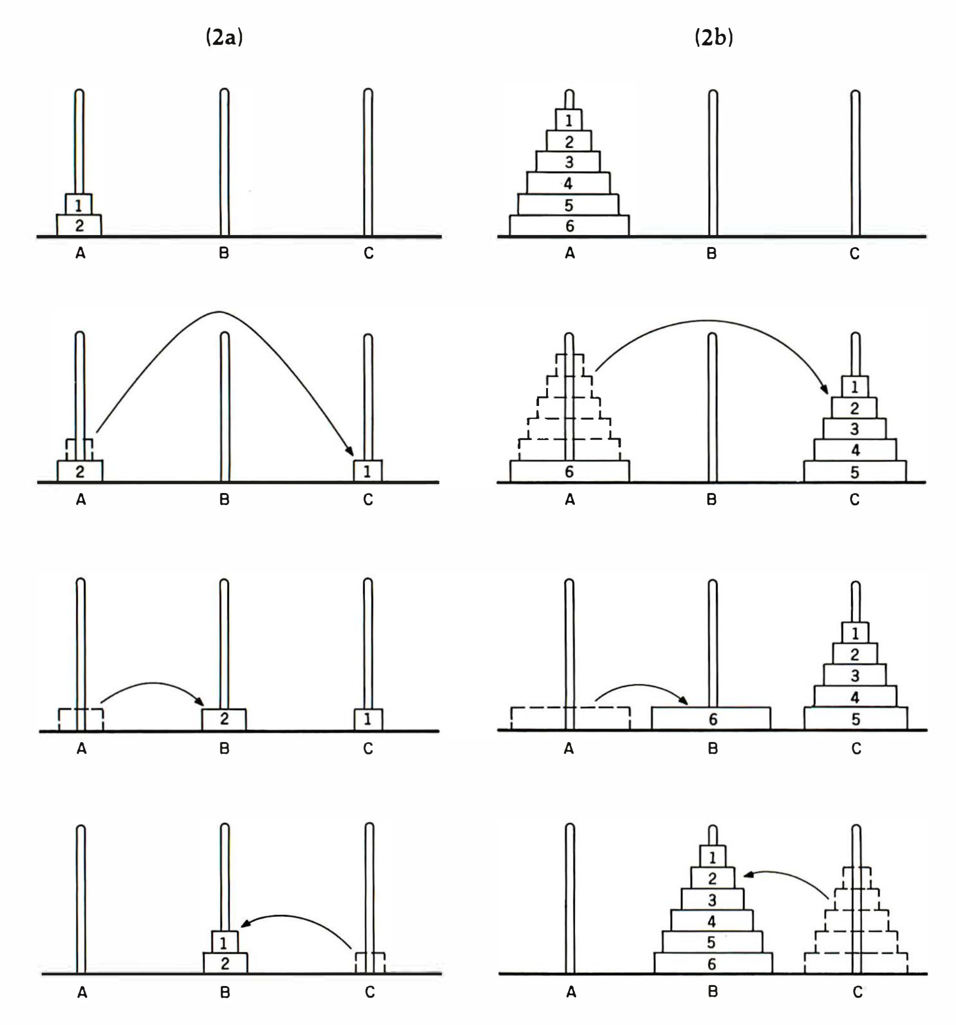


Figure 2: *How the puzzle breaks down into simpler subproblems with similar solutions. Figure 2a shows the simplest solution to a puzzle involving only two disks. Figure 2b shows the situation when the same procedure is used on more disks.*

Listing 2: *General solution to the Tower of Hanoi puzzle in Logo. The program requires four inputs. The variable* NUMBER *tells the program how many disks to the puzzle; the other three inputs are the names of the pegs. The* IF *statement detects the trivial subproblem of moving zero disks, for which there is nothing to do.*

The solution is found by dividing the problem into a series of simpler subproblems, all of which can be solved by repeating a simple series of moves. First, move all but the bottom disk to the third peg; then, move the bottom disk to the destination peg; and finally, move all but the bottom disk to the destination peg (see figure 2).

```
TO HANOI :NUMBER :FROM :TO :OTHER
IF :NUMBER = 0 [STOP]
HANOI :NUMBER - 1 :FROM :OTHER :TO
PRINT (SENTENCE [MOVE DISK] :NUMBER [FROM PEG] :FROM [TO PEG] :TO)
HANOI :NUMBER - 1 :OTHER :TO :FROM
END

HANOI 6 ''A ''B ''C
```

size, while lists can become bigger or smaller as a program executes. (There is no equivalent in Logo to BASIC's DIM statement, which is used to specify how big an array will be.) The second difference is that arrays must be uniform. That is, you can have an array of 12 numbers, or an array of strings each 23 characters long, but you can't have an array of some of both. (A Pascal record or C structure can have some of both, but only in one predeclared pattern.) Each element of a Logo list can be any Logo object: a number, a word, or even another list. Thus, the following are examples of lists:

```
[VANILLA CHOCOLATE MOCHA]

[VANILLA [MINT CHOCOLATE CHIP]
  [FUDGE SWIRL]]

[BANANA 3.14159 [RED BLUE
  YELLOW] 2.71828]

[FLAVORS [VANILLA CHOCOLATE]
  SIZES [LARGE SMALL]
  OPTIONS [[HOT FUDGE]
  [SUGAR CONE]]]
```

The first of these is a list of three words. The second is also a list with three members, but the first is a word and the others are lists. The third example shows that numbers can be included. The last example demonstrates that a list can contain a list that contains a list.

The last example is a special kind of list, called a property list. If this property list were associated with the name ICECREAM, the Logo statement

```
PRINT GPROP ''ICECREAM ''SIZES
```

would print:

LARGE SMALL

(GPROP stands for Get PROPerty.) Property lists are a convenient way to group related information. Imagine, for example, a Spacewar game program with several ships, each with a property list. The properties might be the ship's position, velocity, shape, remaining energy, and so on.

The reason that some languages restrict you to using arrays is that, being uniform and of fixed size, they are



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more efficient to deal with. The restrictions on arrays mean that if the computer knows where the beginning of some array is located in memory, the location of the *n*th element of the array can be calculated easily, no matter what values the elements actually have.

With a list, the size of each element is variable. Therefore, lists are stored in a more complicated way. As a result, to find the fourteenth element, you have to start with the first one, figure out where the second one is, then figure out where the third one is, etc. Since this is all done automatically by the Logo interpreter, lists aren't hard for the programmer to use, but it's somewhat slower than finding something inside an array.

Among major languages, LISP uses lists much like those in Logo. (In fact, the data structures in Logo are based on those of LISP. LISP's name stands for LISt Processing.) APL uses a data structure that is like lists in that it is not fixed in size, but is like arrays in that it is uniform in composition. In other words, an APL vector can grow or shrink, but it has to be all numbers or all characters. Pascal and C don't have lists, but they have pointer variables that can be used along with records or structures to build the equivalent of lists. FORTRAN and BASIC don't have dynamic storage allocation—you can't make something bigger in the middle of the program—so there is no way to create lists in them.

Logo is not typed. In BASIC, if you want a variable to contain a character string, you put a dollar sign at the end of its name. If you don't use the dollar sign, the variable must contain a number, not a string. (Some versions of BASIC have a third type: a variable whose name ends with a percent sign contains an integer, or whole number.) In Pascal and C, the *type* of a variable must be given explicitly in a declaration. In FORTRAN, variables can be declared as in Pascal; if a variable isn't declared, its type depends on the first letter of its name. The letters I through N indicate integer variables.

In Logo, as in LISP and APL, variables are not typed. Any variable can take on any value. The same variable can be an integer at one point in the program and a character string (called a word in Logo) later on.

Originally, variable typing wasn't a matter of language-design philosophy. Variables were typed to make life easier for the people who wrote compilers. Since different machine-language instructions are used, for example, to add integers and to add numbers with fractional parts, it's easier to translate "A+B" into machine language if you know ahead of time whether or not A and B are integers.

More recently, some language designers have taken the position that variable typing is a good thing, apart from implementation issues, because it disciplines the programmer to use a variable for only one purpose. In re-

Listing 3: *Logo variables are nontyped. The variable* NUMBERS *contains whatever the user enters. First, it is examined as a list of words and tested to see if it contains the value* DONE*; next, it is used as a list of numbers and added.*

```
TO ADDLOOP
PRINT [TYPE TWO NUMBERS TO ADD.]
MAKE "NUMBERS READLIST
IF FIRST :NUMBERS = "DONE [STOP]
PRINT SENTENCE [THE SUM IS] (FIRST :NUMBERS) + (LAST :NUMBERS)
ADDLOOP
END
```

jecting typing, the designers of Logo did not mean to encourage the haphazard use of variables for different purposes; rather, they built a procedural language in which variables are attached to a particular procedure, rather than being available to the entire program. This encourages the same discipline in a different way.

As an example in which typed variables are awkward to use, listing 3 illustrates the common problem of writing a program that reads some numbers entered by the user, performs some calculation with them, and repeats the process until the user signals that there are no more problems to do.

This program has been written so that the user can enter the word DONE when no more numbers are left to add. In a typed language, the numbers would have to be read into a numeric-type variable, not a string-type variable. Entering a nonnumeric word would be an error. FORTRAN programs used to be full of instructions to the user like "type 9999 to indicate that you're done." Pascal programs face the same difficulty.

Logo is extensible. Every computer language has certain built-in, or primitive, operations. Most languages, for example, include arithmetic operations on numbers, and some way to print the results. Procedural languages allow the programmer to create new operations, extending the capability of the language. In that sense, most languages are extensible. But "extensible" is used by language designers in a special sense.

An *extensible* language is one in which user-defined procedures "look like" primitive procedures. This is partly a matter of notation and partly a matter of real power. In most languages, the primitive arithmetic operations can be applied to several different types of variables (integer and real, for example) with appropriate results for each type. In most languages, however, user-defined procedures must specify in their definition one particular type of variable to which they apply. This restriction violates the principle of extensibility.

Extensible languages are particularly valuable for teaching because a teacher can provide language extensions and teach them as if they were primitives. LISP, Logo, APL, and FORTH are extensible, with some minor restrictions in some cases. Logo violates pure extensibility, for example, in that some of the primitive arithmetic operations are represented in infix form (with the operation symbol between the two operands, as in 3 + 2), while user-defined procedures can be represented only in prefix form (with the operation symbol before the operands, as in SUM 3 2). Almost all Logo primitives are used in prefix form.

As an example of the use of extensibility in Logo, most versions do not have primitive procedures for iterative looping, like the FOR, DO, or WHILE constructs in other languages. But it is very easy to define these procedures, if you want them, so that they look syntactically similar to the IF command that is a Logo primitive.

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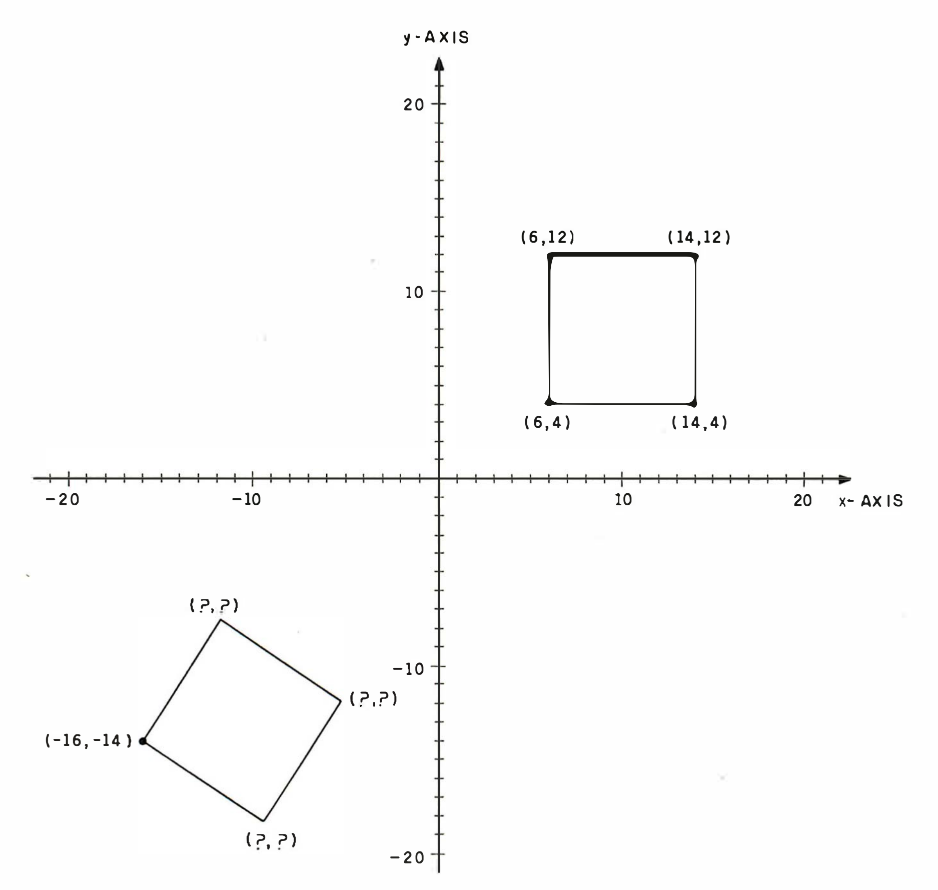


Figure 3: *The difficulties involved in graphics using Cartesian coordinates. A square is simple to draw when its sides are parallel to the axes, but trigonometry is necessary when other orientations are used.*

Logo, LISP, and APL are interpreted, list-oriented, and untyped. Pascal and C are compiled, array-oriented, and typed. (All respectable languages are procedural, by definition.) These groupings reflect historical accidents, implementation convenience, and language-design philosophy. For example, C and Pascal are very similar because they are both derived from an earlier language, ALGOL, that established a style followed by many newer languages.

Compilers have a much easier time with typed languages, while interpreters are just as happy with untyped ones. The list-oriented languages were all invented by people who are primarily mathematicians, rather than computer programmers.

Within each group, though, the differences tend to reflect the particular use each designer had in mind. For example, C is different from Pascal largely because C was designed as a language for systems programming. In the list-oriented group, LISP was developed for use in artificial-intelligence research, and APL was developed to teach algebra and the mathematical topics, like calculus, that depend on algebra. Logo, though, was developed as a learning language, not for a specific branch of mathematics, but for problem-solving behavior. Logo is meant to appeal particularly to younger students than APL does, although Logo has also been used successfully with college physics students at MIT.

From the point of view of the "pure" computer scientist, Logo is LISP. The developers of Logo, in fact, have been artificial-intelligence researchers for whom LISP is second nature. The differences between the two languages are all based on the specific intent to make Logo particularly useful as a learning language. Logo's special properties from this point of view will be described next.

Logo is "tuned" for interesting applications. Probably the most famous aspect of Logo is the idea of *turtle geometry*. This approach to computer graphics has been added to other languages, such as Pascal and PILOT, but it originated with Logo.

Most approaches to computer graphics are based on Cartesian coordinates (the "x,y" system you learned for graphing equations in high school—see figure 3). In this approach, each line you want to draw is specified in terms of the specific positions of the endpoints, relative to a fixed-coordinate system. Using Cartesian coordinates, it's not too hard to draw an upright square in a known position, but if the square is tilted, its coordinates must be calculated using trigonometry. The power of turtle geometry is that lines are described not in terms of absolute position in a coordinate system, but relative to the position and direction of the turtle, a conceptual animal that moves around the TV screen. In this system, you don't say where the turtle starts or ends, just how far it moves and in what direction:

```
TO SQUARE :LENGTH
REPEAT 4 [FORWARD :LENGTH
          RIGHT 90]
END
```

Other articles in this issue of BYTE explain more about how turtle geometry works (see "A Beginner's Guide to Logo" by Harold Abelson on page 88 and "Introducing Logo to Children" by Cynthia Solomon on page 196). For our purposes, what's important is that the use of this powerful approach makes graphics programming possible for beginners the first time they use the computer.

In the past, computer programming has appealed to only a small number of people because there has been a real lack of problems that are both interesting and easy enough for beginners. Traditional programming courses have been heavy in algebraic problems ("Write a program to solve quadratic equations."). Therefore, they have not attracted people who

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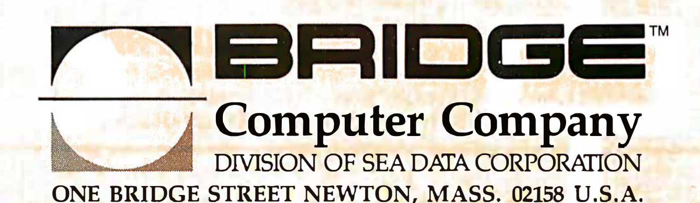
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Listing 4: *Pig Latin translation via Logo.*

```
TO PIGLATIN :SENT
IF EMPTYP :SENT [OUTPUT []]
OUTPUT SENTENCE (PLWORD FIRST :SENT) (PIGLATIN BUTFIRST :SENT)
END

TO PLWORD :WORD
IF VOWELP FIRST :WORD [OUTPUT WORD :WORD "AY]
OUTPUT PLWORD WORD BUTFIRST :WORD FIRST :WORD
END

TO VOWELP :LETTER
OUTPUT MEMBERP :LETTER [A E I O U Y]
END
```

don't like the traditional mathematics curriculum.

Turtle geometry is not the only special application built into Logo. Another one is language processing. Letters, words, and sentences are a natural hierarchy of Logo objects. (In most programming languages, by contrast, a sentence is not a list of words, but a string of characters. If you want to deal with the words in the sentence, you have to write a complicated program just to look for spaces in the string to divide the words.) As a simple example, listing 4 is a Logo program to translate a sentence into pig Latin. PLWORD is used as a subprocedure to translate a single word based on this rule: if the word starts with a vowel, add AY at the end. If not, move the first letter to the end and try again.

In the program, WORD and SENTENCE are procedures for joining two objects into a larger object; FIRST and BUTFIRST separate an object into its component parts. The primitive procedure FIRST, when applied to a sentence, produces the first word of the sentence. When applied to a word, it produces the first letter. No other programming language deals so neatly with this hierarchy of objects in human language.

Logo is user-friendly. A language for learners has to be designed to deal with problems that are less important in a language meant for experienced programmers. For example, when you make a mistake, you should get a detailed, helpful error message. Languages that say things like SYNTAX ERROR or ERROR NUMBER 259 are not encouraging to a beginner. Logo has messages like:

+ DOESN'T LIKE HELLO AS INPUT

This means that you tried to add a nonnumber, the word HELLO, to something. When you see the message

I DON'T KNOW HOW TO FRIST

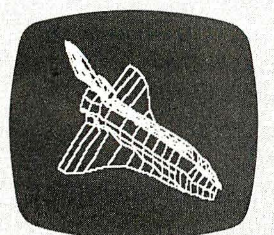
you have used a procedure, FRIST, that you haven't defined. The message

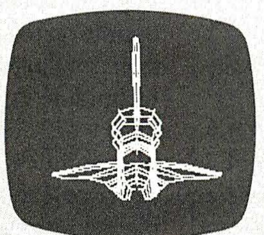
NOT ENOUGH INPUTS TO MAKE

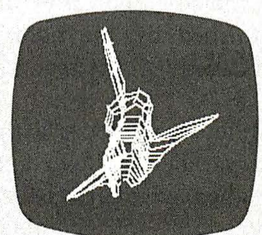
means that the procedure MAKE needs two inputs, and you gave only one. If the error happens during the execution of a procedure, Logo also prints the name of the procedure and the line containing the error.

Since the beginning of time (in 1954), programming students have been getting confused about common programming statements such as X=X+1, a frequently used assignment construct that seems to go against one's algebraic intuition. Pascal's use of := instead of the unadorned equal sign is somewhat of an improvement, and APL's ← is even better. Even so, the notation doesn't make it obvious that X ←3 has an effect very different from X+3 or X−3, which look very similar. In Logo, the assignment is done this way: MAKE "X :X+1. Although less terse than a single-character symbol for assignment, the word MAKE con-

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jures up much more vividly the notion that something is being changed, not just used in a calculation.

There are many more ways in which Logo makes explicit things that many languages leave hidden. For example, Logo uses the colon (which Logoites call "dots") to mean "I want the value of this variable"; the same word without the dots names a procedure. In LISP, the notorious parentheses make it possible to distinguish procedure calls from variable references without the dots notation; most other procedural languages simply prohibit using the same word for both purposes. (That solution would be awkward in Logo because some words like WORD are not only popular variable names, but also names of primitive procedures.)

In any case, according to the design philosophy of Logo, the dots notation is a good thing, apart from its technical necessity, because it calls attention to the fact that a variable's value is different from its name; it also points out that a variable is different from a procedure. For example, in the X=X+1 situation, the two identical-looking appearances of X have different meanings. The second represents the old *value* of X, whereas the first merely *names* the variable being given a new value. In the Logo version, these two meanings are distinguished by the notation. The first is called "X; the second is called :X.

Another example of a distinction that is explicit in Logo and not in some other languages is the division of procedures into commands and operations. An operation is a procedure that computes some value that becomes the output of the procedure. For example, the arithmetic operations are in this category. A command does not have an output, but instead has an effect: it prints something, moves the turtle, or changes the value of a variable.

The same distinction is made in Pascal, in which operations are called functions and commands are called procedures. FORTRAN calls them functions and subroutines. LISP, APL, and C, however, are less fussy. C treats all procedures as operations, but allows an operation to be used as if it were a command; the result of the operation is ignored in that case. In LISP and APL, the result of such a "top-level" operation is printed. (In LISP, every procedure has an output and every top-level command prints something. In APL, some procedures don't have output and, therefore, don't print anything.) In Logo, using an operation without a command is considered an error; if you want something printed, you must use the PRINT command.

The use of infix arithmetic in Logo is a concession to the habits of the users. All other Logo procedures are used in prefix form, with the procedure name before the inputs. Arithmetic can also be expressed in prefix form. The two Logo expressions 3 + 2 and SUM 3 2 are equivalent.

The infix form seems more natural to people accustomed to doing arithmetic outside of the Logo environment. The prefix form, however, is better in some ways. For example, it eliminates the need for precedence of operations (i.e., where division is always done before addition, etc.). Also, it eliminates the need for parentheses to indicate grouping. In LISP, only the prefix forms are used.

Another user-friendly aspect of Logo is its facility for interactive definition of procedures. Early versions of Logo used a line-numbering technique: within each procedure, lines were numbered and could be replaced much as the lines of a BASIC program can be replaced. Current implementations of Logo use a display editor in which special control characters are used to move the cursor around the display screen to change individual characters anywhere in a procedure definition.

Logo has no threshold and no ceiling. This means that Logo is easy enough for anyone to use, but it is powerful enough for any project; it's not a "toy" language. Logo is best known as a language for elementary school children, but it's designed for learners of any age and any level of sophistication.

How young can a Logo learner be?



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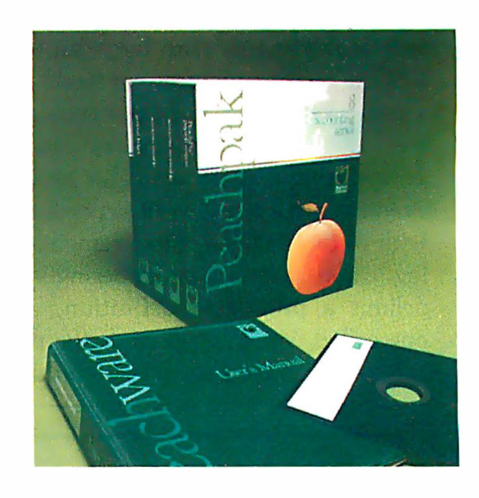
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Well, very young children might have trouble with typewriter keys and with the spelling of procedure names. Several years ago, however, Radia Perlman at MIT built a series of special keyboards with large buttons labeled with pictures instead of words. With this special hardware, she taught the ideas of turtle geometry to 4-year-olds. This project even included the idea of procedures, with buttons called "start remembering" and "stop remembering" to delimit a procedure definition, and one called "do it" to execute the procedure. Multiple procedures could be named by using buttons in different colors.

How old can a Logo learner be? Professors Harold Abelson and Andrea diSessa have been using Logo to teach physics to MIT undergraduates. They use Logo simulation programs to demonstrate not only simple Newtonian mechanics but even the general theory of relativity. Their book, *Turtle Geometry: The Computer as a Medium for Exploring Mathematics* (Cambridge, MA: MIT Press, 1981), demonstrates their approach, which has also been used successfully with high school students.

Logo has also been used for a special group of learners, those with severe handicaps. In the past, many children of normal or superior intelligence, but with impaired ability to communicate, have been diagnosed as retarded. Computers can be used with such children both as a communication prosthesis and as a field of interest in which the handicapped learner can exhibit autonomy in pursuing goals. The use of Logo in education for the handicapped is explored in Dr. E. Paul Goldenberg's book *Special Technology for Special Children* (Baltimore: University Park Press, 1979).

Other languages designed with students in mind are BASIC, Pascal, and APL. (I omit PILOT, which was designed not so much for students as for teachers; in its original design, students were supposed to use computer-aided-instruction programs written in PILOT, rather than PILOT itself.) How do these languages compare with Logo in their applicability to education?

BASIC was designed as a modification of FORTRAN for beginners. By far the most important advance in BASIC was its interactive approach. This was much more of a pioneering step than it now seems because people are now accustomed to inexpensive personal computers with this feature. In the early days of BASIC, the only computers were huge, expensive ones. Although timesharing, which allowed several people to use the big computer at once, had recently been invented, many people objected to it because it used the precious time of the huge computers inefficiently. (The response of timesharing advocates was that it was more efficient in the use of human time.) An interactive language was even more time-consuming than timeshared use of the old, compiled languages. For John Kemeny and his colleagues at Dartmouth to move against the general worship of efficiency was very brave.

Besides adding interaction, BASIC removed some of the most difficult parts of FORTRAN. For example, the INPUT and PRINT statements in BASIC don't require a detailed specification of the format in which infor-




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mation is presented, as FORTRAN does with its FORMAT statement. (As an example, FORTRAN requires the user to specify the number of digits before and after the decimal point in the printed form of a number.) Of the modern languages, only C uses primarily format-directed input and output. Unfortunately, the important ideas of procedures and local variables were also left out of BASIC.

This means that easy problems are very easy to solve in BASIC, but hard problems are close to impossible. Any large BASIC program is bound to be an unreadable maze of GOTOs. The designers of BASIC, after all, intended it as a language for beginners (i.e., Beginner's All-purpose Symbolic Instruction Code). FORTRAN was supposed to be used for more difficult programs.

The advent of personal computers has pushed BASIC into a more extended role, not because it's easy for the programmer, but because it's easy for the computer! The Logo interpreter, like the Pascal compiler, barely fits in an Apple II computer with 64K bytes of memory. BASIC interpreters are used with 8K-byte machines at a much lower cost. The result is that computer magazines are filled with long, complicated BASIC programs that are far from basic in their readability.

Pascal, on the other hand, was designed to include the most advanced ideas of computer science in recent years. Although intended as a first language, it was meant primarily for college students, particularly those interested in computer science as a career. That helps to explain why it is compiled and typed, two strong barriers to the unsophisticated student. Even the simplest Pascal program is rather complicated to write, enter into the computer, and run. That's why, in practice, Pascal is often taught to students who have already used BASIC and FORTRAN.

BASIC and Pascal were both designed to teach computer programming per se. APL was designed to teach mathematics, especially at the high school level. Its inventor, Kenneth Iverson, used it for several years as a blackboard language without any intention of actually implementing it on a computer. That helps explain his willingness to use special symbols not then found on any actual computer printer. Anything can be drawn on the blackboard!

In its intended use, APL is very powerful. Many computations that require iterative loops and auxiliary variables in other languages can be done in one step in APL. Most people see this power mainly as a matter of terseness; APL is famous (or notorious) for its one-line programs. The real virtue of APL's approach is that it allows the student's attention to be focused on the mathematics of a problem, rather than on the needs of the computer. APL was designed to be used not in a special programming course or a special unit stuck into another math course, but casually throughout an algebra course, just as you'd use a calculator.

Logo's goal is different from all these. It isn't supposed to be an easy introduction to something else, it's not specifically for computer-science majors, and it isn't a tool for teaching the same math curriculum people are already teaching. Instead, it's a door into the territory of the computer as an object for intellectual exploration. To return to the theme stated at the beginning of this article, Logo is for learning learning.

Why Logo?

In his book *Mindstorms: Children, Computers, & Powerful Ideas* (New York: Basic Books, 1980), Seymour Papert says, "It is not true to say that the image of a child's relationship with a computer I shall develop here goes far beyond what is common in today's schools. My image does not go beyond: It goes in the opposite direction." Logo isn't just a programming language; it's also a philosophy of education. Papert's book is the best explanation of that philosophy, but what follows is a briefer summary.

A child learns partly by picking up specific facts and skills. Much of existing formal education is about facts and skills: reading, spelling, and the multiplication table. But a more profound kind of learning is the skill

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of learning itself, which involves the building of mental models of the world, of oneself, and of the learning process. These models are developed through intellectual exploration. That exploration may begin in a weak, haphazard way, but a good learner develops strategies for purposeful exploration. The more one learns, the better the model of learning, and the more able one becomes as a learner.

In this process of growth, it doesn't really matter what particular aspect of the world you explore. In the introduction to *Mindstorms*, Papert mentions that at age 2 he fell in love with automobile gearboxes. When I was in junior high school, I fell in love with hypnotism. The point about using computers in education is not that everyone must know something about computers, but simply that for many people, computer programming can be the arena for this general process of learning to learn. Because the computer is such a general-purpose machine, it can appeal to many different interests. It can draw pictures, make music, write stories, or move robots.

"I want a job as a computer programmer. Why should I learn Logo, and not something useful like COBOL?" This is a common question. There are two possible answers to it. The first is that Logo, as explained earlier, is designed to make explicit many of the fundamental ideas of computer programming. Someone who learns Logo is likely to have a very clear idea of the nature of variables, procedures, and most other programming constructs. So Logo may be a better basis even for learning COBOL than simply starting with COBOL itself. But the second answer is that Logo's purpose isn't to train computer programmers. Logo isn't meant to replace all other programming languages.

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children because most people have a model of the learning process in which children learn and adults don't. This model is unfortunate. Logo can be useful to people of any age, but it will be most useful to you if you approach it in a playful, exploratory way.

It's important to distinguish between the Logo language and any particular implementation of Logo. Some things can't be done in the Apple and Texas Instruments versions of Logo simply because the machines aren't big or fast enough or because the implementation doesn't include some capabilities. For example, no microcomputer version of Logo has a good way of storing data on disk, although all versions can store procedures on disk.

The Logo interpreter barely fits in a 64K-byte Apple II, and the implementation favors the features needed for education, not those needed for practical data processing. But in principle, Logo is a good language in which to develop any application because of its interactive debugging and its procedural style.

Do you want to write a video-game program? It'll probably run too slowly in Apple Logo, unless it's a simple one. But it might be worthwhile to develop it in Logo, playing around with different ideas for your game in an environment that permits quick, easy modification of your program, and then rewrite it later in some other language. The advantage of Logo can be described partly in purely technical terms like "interactive." Another way of looking at it, however, is that Logo encourages the playfulness you need to design the best possible game. If all you want to do is make an exact copy of Asteroids, the benefits of Logo are less important.

In summary: Logo is a LISP-like language, and a laboratory for loose, lifelong learning about learning. ■

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Introducing Logo to Children

Teaching Logo requires an awareness of different learning styles.

Cynthia Solomon
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As computers continue to enter schools and homes, parents, teachers, and children face the problem of integrating the machines into their lives. For many, computers serve as powerful instruments for personal use and intellectual development. Many Logo researchers see the potential of computers to serve as personal instruments for everyone and have been working toward that goal. In the process, they have focused on developing not only the Logo language, but things to do with the language and ways of thinking and talking about these activities. How people talk about what they are doing, the way they interact with one another, and the way they interact with the computer give rise to a new kind of culture, a computer culture.

Seymour Papert has been the guiding influence in the development of this kind of computer culture. (See *Mindstorms: Children, Computers, & Powerful Ideas* [New York: Basic Books, 1980] for a fuller discussion of Logo and computer cultures.) Papert created the Logo language for children. Although it had to be simple to learn, it needed a rich and easily expandable vocabulary. It had to reflect some of the important ideas in computer science, such as procedurization, local and global variables, naming, self-referential programming, etc. These are attributes that a language such as BASIC does not possess. BASIC has a reputation for being easy to learn; it has a small vocabulary of key words. But this initial set of key words is not easily expandable; the programmer cannot create new key words. This sets BASIC apart and makes it *easy to learn but hard to use*. The programmer cannot build procedures, name them, and then use them to build other procedures. The powerful problem-solving strategy of breaking problems into smaller and smaller parts can only be a paper-and-pencil strategy in a BASIC programming environment. The structure of BASIC does not support this important problem-solving strategy.

For many, computers serve as powerful instruments for personal use and intellectual development.

Once Logo was developed for children, Papert and his collaborators looked to the computer to provide an environment in which a person could learn by doing and thinking about what they did. A person would actively explore the capabilities of both Logo and the computer by constructing objects and debugging them. The computer would serve as a source or tool for creating interesting mathematical objects that would draw upon a person's intuitive knowledge and that could be used in constructing other objects. One of these objects is the computer-controllable geometric entity, now widely known as a turtle. Exploring the turtle's behavior leads people to draw upon their intuitive geometric knowledge. This knowledge does have a formal aspect as expressed in the area of mathematics known as computational geometry. (See *Turtle Geometry: The Computer as a Medium for Exploring Mathematics* by Harold Abelson and Andrea diSessa [Cambridge, MA: MIT Press, 1981] for an excellent presentation of

About the Author

Cynthia Solomon, formerly vice-president of Logo Computer Systems Inc., participated in the development of Apple Logo. She is currently finishing work toward her doctorate in education from Harvard University.

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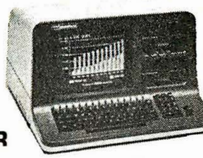
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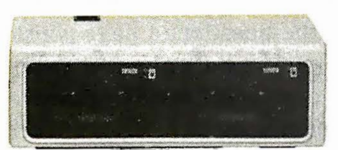
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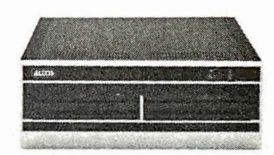
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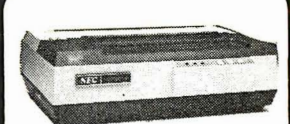


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the formal aspects of turtle geometry.) In this kind of a computer culture, people draw upon knowledge acquired in other activities; and they apply what they learn in the Logo culture to many different areas.

My personal contributions toward this goal focus on what is required to encourage the development of computer cultures in the Logo spirit. One of the questions I have considered is: What does a teacher of Logo have to know? There is no one answer to this question. I have seen children teach other children about Logo. Although their knowledge is quite different from the adults who taught them, the children were very successful at sharing with each other a way of thinking and talking about computers. Perhaps I should pose a different question and ask: What are some of the things I think about as I teach people to program?

I see much of my own development as a teacher as acquiring (1) a collection of programming projects that make the power of programming techniques and concepts apparent to beginners; (2) a vocabulary for talking about programming; (3) an awareness of different learning styles and strategies for building on them; and (4) a sensitivity to the kinds of resistances that keep many adults and children from experimenting with mathematical ideas.

A Model for Introducing People to Computers

When I enter a new teaching situation, I have in mind several models of how to introduce people to Logo. I also maintain a willingness to switch from one model to another or even diverge from all of them. My primary goal is for people to do something they could not have done without a computer, but something that is familiar to them (e.g., draw a square or print their name all over the screen). I also want to think toward a next step and how the beginning programmer can build on what happened in the first session in the following one. Flexibility is one of the most powerful ideas in this culture, but to be flexible implies having a model to

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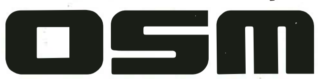
"But how, dear man," I interjected, "did you deduce that a power glitch was to blame for last night's loss of data?"

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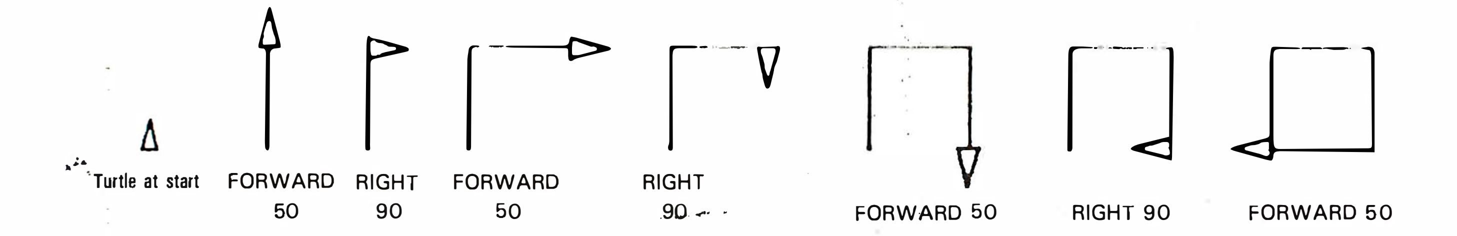


Figure 1: *Building a square. With the turtle at the starting point, this sequence of commands will produce a square. These commands can also be turned into a Logo procedure.*

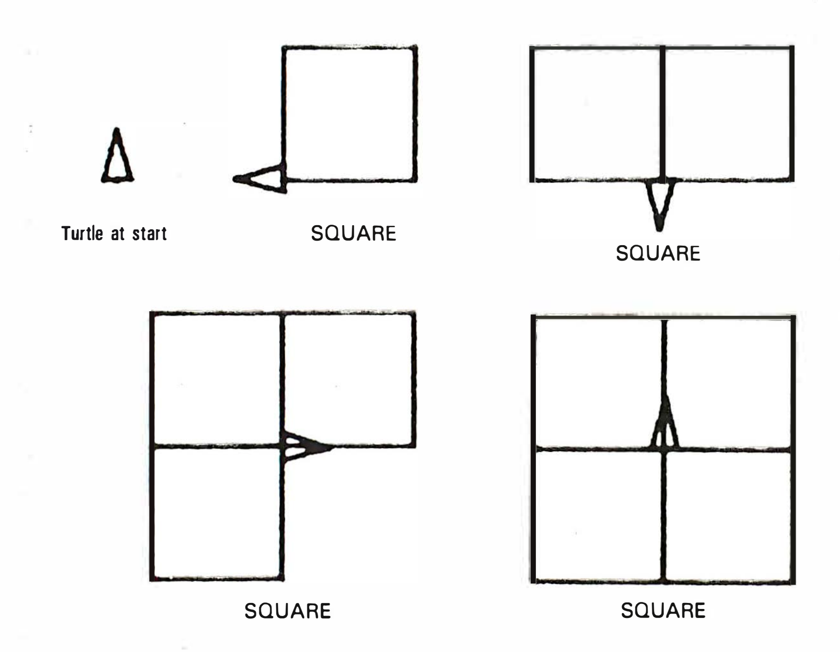


Figure 2: PANES *as evolved from* SQUARE. *The figure is made by repeating the* SQUARE *procedure four times.*

depart from. Thus, I have a model in mind of paths a beginner might take in a first session.

In a first session, I try to convey the following ideas: (1) programming is a process of engaging the computer in conversation using the vocabulary the computer understands; (2) the computer's understanding can be easily expanded; (3) giving meanings to words involves describing a procedure to the computer and giving the procedure a unique name; (4) since procedures created by the programmer can be used like any of Logo's words, they can be incorporated into other procedures; (5) making procedures entails a process of debugging; and (6) pretending to be the computer or the turtle helps in designing and debugging programs.

Thus, in a first session, a person might try out turtle commands like FORWARD and RIGHT. The student would then make a design (create a procedure), give it a name, enter that name into Logo's active vocabulary, and use that new procedure in the construction of others. The teacher, at the same time, is also learning from this experience by thinking about the effect of different actions on the turtle and, with concrete examples and advice, helping the new Logo programmer arrive at a greater understanding of Logo. The teacher also has a chance to rethink the examples presented to the student and develop new approaches and a deeper understanding of the learning process. (See *Apple Logo: Introduction to Programming through Turtle Graphics* by Cynthia Solomon [Pointe-Claire, Quebec: Logo Computer Systems Inc., 1982], which is included in the Apple Logo package.)

Example of a First Session

Usually, a beginner starts by communicating with a turtle. The student specifies an algorithm in Logo that causes the turtle to draw a geometric design (e.g., a square). This is done relying on intuitive mathematics instead of formula-driven mathematics. That is, the description to the computer is based on how the student would trace out the path of a square if the student had the same limited understanding as the turtle does (e.g., knowing how to move FORWARD or BACK, and turn LEFT or RIGHT). The sequence in figure 1 illustrates the effect of such commands on the turtle. These commands can be named and turned into a procedure that then becomes a part of Logo's working vocabulary:

```
TO SQUARE
FORWARD 50
RIGHT 90
FORWARD 50
RIGHT 90
FORWARD 50
RIGHT 90
FORWARD 50
END
```

The TO informs Logo that a procedure is being created. SQUARE is the name of the procedure. END marks the end of the text of the procedure. Now the programmer might use the SQUARE procedure to produce a new design like the one in figure 2, created by PANES, which follows:

```
TO PANES
SQUARE
SQUARE
SQUARE
SQUARE
END
```

The beginner gets an immediate sense of the relationship between program and goal and rapidly elaborates this into an understanding of the relationships among goals and subgoals, procedures and subprocedures (e.g., the programmer learns that PANES is made by running the SQUARE procedure four times). The beginner is involved in debugging, in learning by doing and thinking about the process. (For example, the programmer may create a square that doesn't close. Listing the procedure, the student catches a bug in the input to FORWARD when drawing the last side of SQUARE; it should be FORWARD 63, not 36.) The programmer may use anthropomorphism or identification as a debugging aid (e.g., pretending to be the turtle causes a person to walk in the same path as the turtle would, and it also helps to understand the turtle's behavior). Thus, in a first session, a programmer writes a procedure that then becomes part of Logo's working vocabulary. In doing this, the programmer achieves a sense of the power available to influence the environment and a sense of accomplishment and creativity.

A Model of Learning Styles

I have observed that children take over the computer in different ways. They show different learning styles, different paths into the computer work. Undoubtedly, this bare statement is true for all learning. What is special here is that the flexibility of the computer allows the process to go further and become more explicit. In working with computers, many paths lead to the same goal. Moreover, many equally great goals can be pursued. This gives children the opportunity to express themselves and explore their own intellectual styles.

In working with computers, many paths lead to the same goal. Moreover, many equally great goals can be pursued.

Although each child has a unique intellectual personality, and the use of the computer allows us to respect it, we do observe some similarities. I shall describe three distinct learning styles that have emerged, not only from my own work with young children, but from work completed by Dan Watt as part of the MIT-Brookline Logo Project.

The first learning style I call the planner. This child might build structured programs from the top level down or from the bottom level up, but always from a coherent formulated plan.

A second learning style is the macro-explorer. This student likes to mess about with subprocedures or building blocks to arrive at a product,

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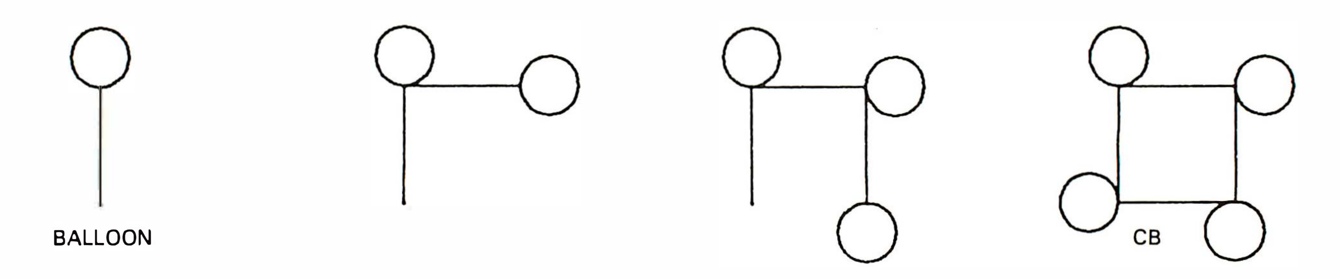


Figure 3: CB *as evolved from* BALLOON. *Using techniques developed to build* SQUARE, *6-year-old Janet designed* CB *from the procedure* BALLOON.

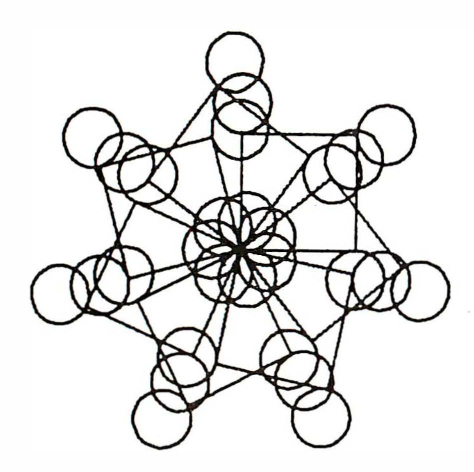


Figure 4: FLOWER, *also designed by Janet, is created by using the procedure* CB, *but turning the turtle 51 degrees and repeating the procedure seven times.*

rather than starting out with a specific goal. In this case, the learner is intent on exploring the effect of the particular building block. Therefore, the result is open-ended.

Finally, some learners have to explore their environment on a micro-level before they can establish patterns of planning or directed exploration. These micro-explorers are often the most timid learners, doing such things as assuring themselves that FORWARD 100 is the same as FORWARD 1, FORWARD 9, FORWARD 11, FORWARD 23, and FORWARD 56. Others might exhibit this conservative, gradual exploration by using the same numbers as inputs to FORWARD and RIGHT, or by repeating the same commands over and over.

Any child might use all three of these learning styles. In an initial session, I might try to "plant seeds" for all three. For example, I would encourage a beginning student to drive the turtle around the screen in a series of direct commands with no goal other than to understand the turtle's behavior. But in the same initial session, I would suggest some concrete goal, such as making the turtle walk in a square or, perhaps, having placed some squares on the screen, I would ask the child to make the turtle touch them. In this, I elicit primarily a micro-explorer style with some hint at a planner style.

I facilitate a macro-explorer style by seizing on something interesting the child has just done and suggesting "teaching" it to the computer. Thus, I encourage the child to form procedures, thereby turning the turtle meanderings into repeatable procedures or building blocks. Using these procedures, the child can create more unanticipated designs.

I would encourage children to follow a planner style of learning by asking them to choose a design from a collection of procedures already familiar to them or by asking them to make a design of their own and use these as procedures. Being sensitive to these styles of learning and their natural intermixing helps to develop strategies for guiding the children. These styles of learning are exhibited by novices to programming in Logo regardless of their age.

Using Procedures

Janet, a 6-year-old, had previously made a square. In constructing CB (see figure 3), she used similar techniques. She made the turtle draw BALLOON and then turn RIGHT 90 repeatedly until it had walked in a complete path and returned to the position and heading it started from. Janet was not aware of this as a generalization, but her specific experiences led her to believe that these two actions repeated over and over resulted in the turtle making a complete trip, i.e., return to its starting state.

Next, FLOWER (see figure 4) was made by running CB, turning the turtle 51 degrees, and repeating these two actions six more times. Why 51 degrees? Well, Janet just happened to pick that number. Why did 51 have that effect on CB? The answer lies in the fact that turning the turtle 51 degrees seven times results in a total turning of 357 degrees, which is very close to a complete rotation of 360 degrees. In this situation, Janet was satisfied; for her purposes, the design was complete.

A more interesting question is: How did she know to probe the turtle environment in this way? She knew certain facts about turtles and turtle-directed procedures that she had gained from her experiences with the turtle. For example, if the turtle draws something and doesn't return to its starting state, repeat the procedure. Something interesting will happen and eventually the turtle will come back to where it was initially. On the other hand, if the turtle does return to its starting state when it makes a design, change the turtle's heading and run the program again. In other words, Janet did not need the teacher's knowledge about the power of 360 degrees. Rather, she needed the idea of the total turtle trip that, translated into intuitive knowledge, told her to keep repeating an action until the turtle returned to its starting state. Janet's learning style in this project

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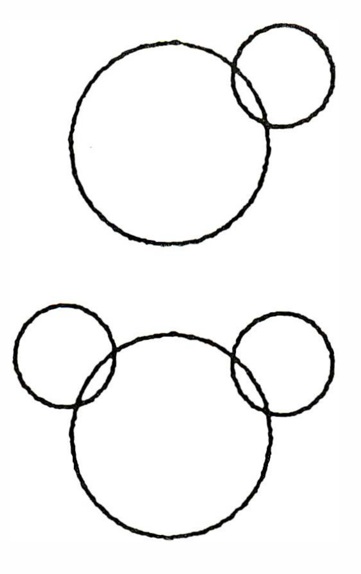
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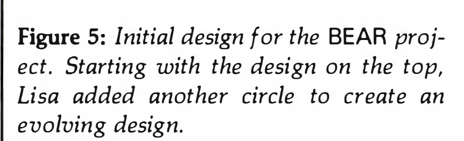


Figure 5: *Initial design for the* BEAR *project. Starting with the design on the top, Lisa added another circle to create an evolving design.*

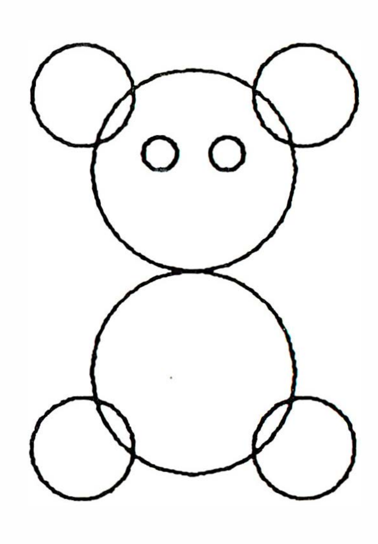


Figure 6: *Completed* BEAR. *Repeating the procedure to create the head, Lisa modified her learning style and created this design.*

and many others was that of a macro-explorer.

The BEAR project was initiated by Lisa, an 11-year-old from an inner-city school close to MIT. Lisa approached the project as a micro-explorer. Although she had previously written several procedures, Lisa showed great resistance to using them as building blocks. For example, after constructing a square procedure, she tried to reconstruct a square, as other micro-explorers might, by telling the turtle to move in incremental steps, e.g., FORWARD 11, FORWARD 9, etc.

I asked her to play with circles using CIRCLER or CIRCLEL procedures, which require the radius as input. I encouraged her to try using circles of different sizes. She made the circles shown at the top of figure 5. I then encouraged her to do the same thing on the other side of the larger circle, as shown at the bottom of figure 5. When asked what it reminded her of, she thought it looked like a bear's head. She then added the eyes and used the head for the body (see figure 6). In so doing, I helped her shift modes from micro-explorer to planner.

This project illustrates clearly that many ways can be used to arrive at a particular goal. Picking a starting state for the turtle influences the construction of the procedure. Whether the job is thought of in terms of subprocedures or whether the design is first created by the student (whether by the mind's eye or on paper) and the turtle is made to trace the path etched on paper has important consequences in how the project is developed.

If the design is to be taught to the turtle by breaking it up into parts, the programmer has to decide what building blocks are needed. This BEAR has several interesting features. It is made entirely of circles. The head and the body are identical. The project is easily changed to focus only on the head or to create, with minor modifications, a different animal (see figure 7).

Both Lisa and I benefited from this project. She became a more confident problem-solver and tended to move away from her micro-explorer style of probing. She used a powerful mathematical idea, symmetry, in a playful but personally meaningful way, and used it throughout her project. I, on the other hand, added to my collection of programming projects. We both followed our intuition. I was

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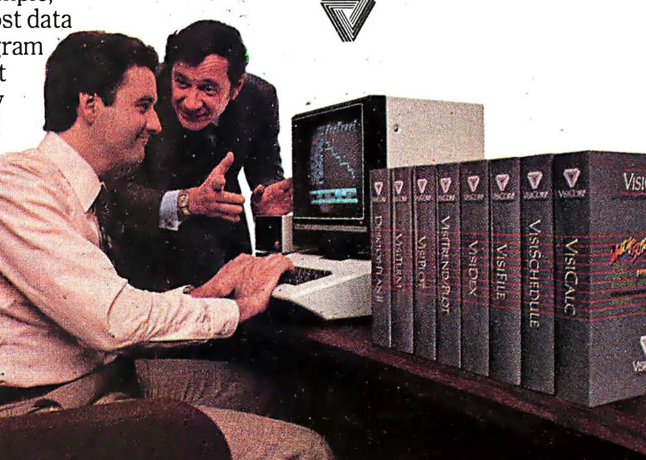
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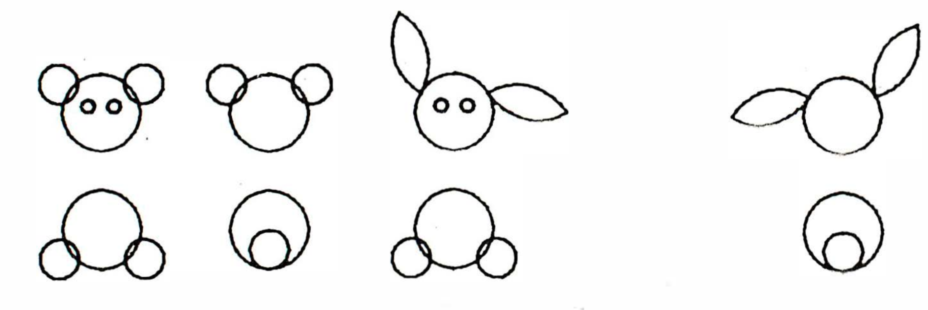


Figure 7: *Other animals created by modifying the* BEAR *procedure.*

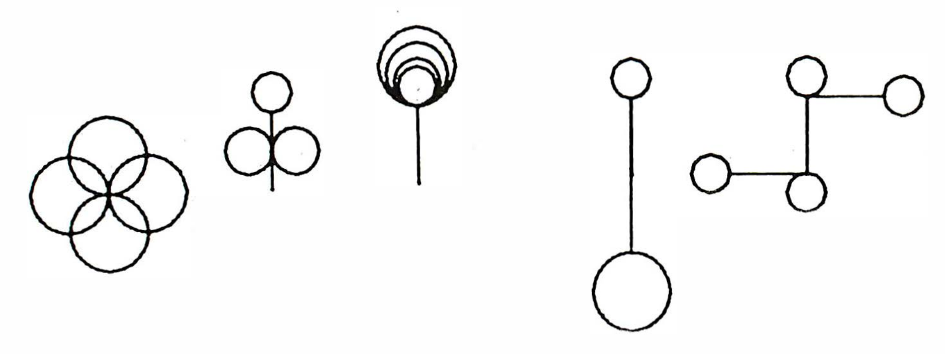


Figure 8: *Other designs created by Lisa using Logo.*

hopeful that when Lisa used circles as building blocks she would discover some lovely thing to make with them, and she did.

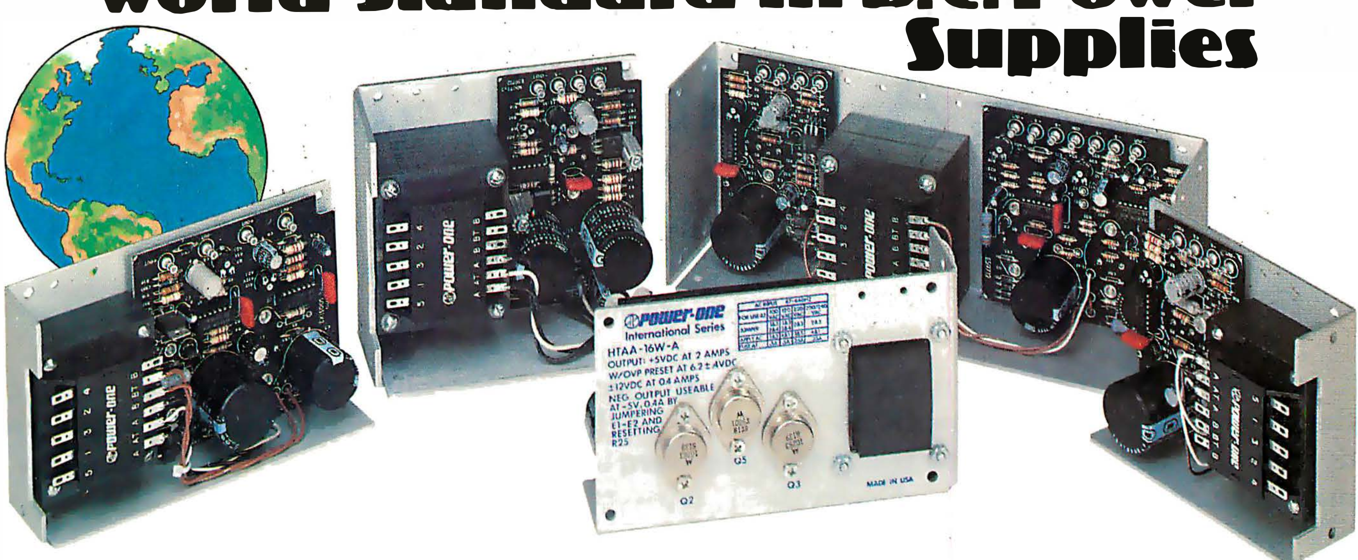
A Model of Teaching and Learning as Debugging

Turtle geometry is but one part of the Logo computer culture. Other areas of activity have been explored and many more are waiting to be explored. Turtle geometry, however, serves to illustrate key characteristics of the culture, in particular, the idea of exploring an environment and the objects in it by manipulating them through a complex of interactions based on procedural descriptions. By elaborating the descriptions through debugging (testing procedures in real situations), getting concrete feedback on these actions, and adjusting the initial descriptions to take into account these results, a person's exploration in Logo will be furthered. The process of procedural description and debugging might be seen as a dynamic process of assimilation and accommodation, of making theories and revising them as a result of experience and knowledge, but doing this playfully as an enjoyable activity involving one's whole self.

Conclusions

Sharing in this learning process is a self-empowering experience for all participants. A different way of looking at learning and teaching emerges, one based on the Piagetian idea that even very young children have theories. Thus, teaching and learning are not a matter of being wrong or right, but rather a process of debugging. Learning and teaching are intertwined and become a process of developing debugging aids as knowledge gaps are discovered and filled in. The persons using computers are cast in the role of both student and teacher as they actively participate in development of the computer culture. They contribute to its richness and enrich their own lives. ■

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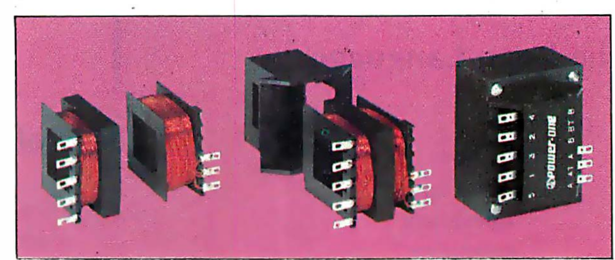
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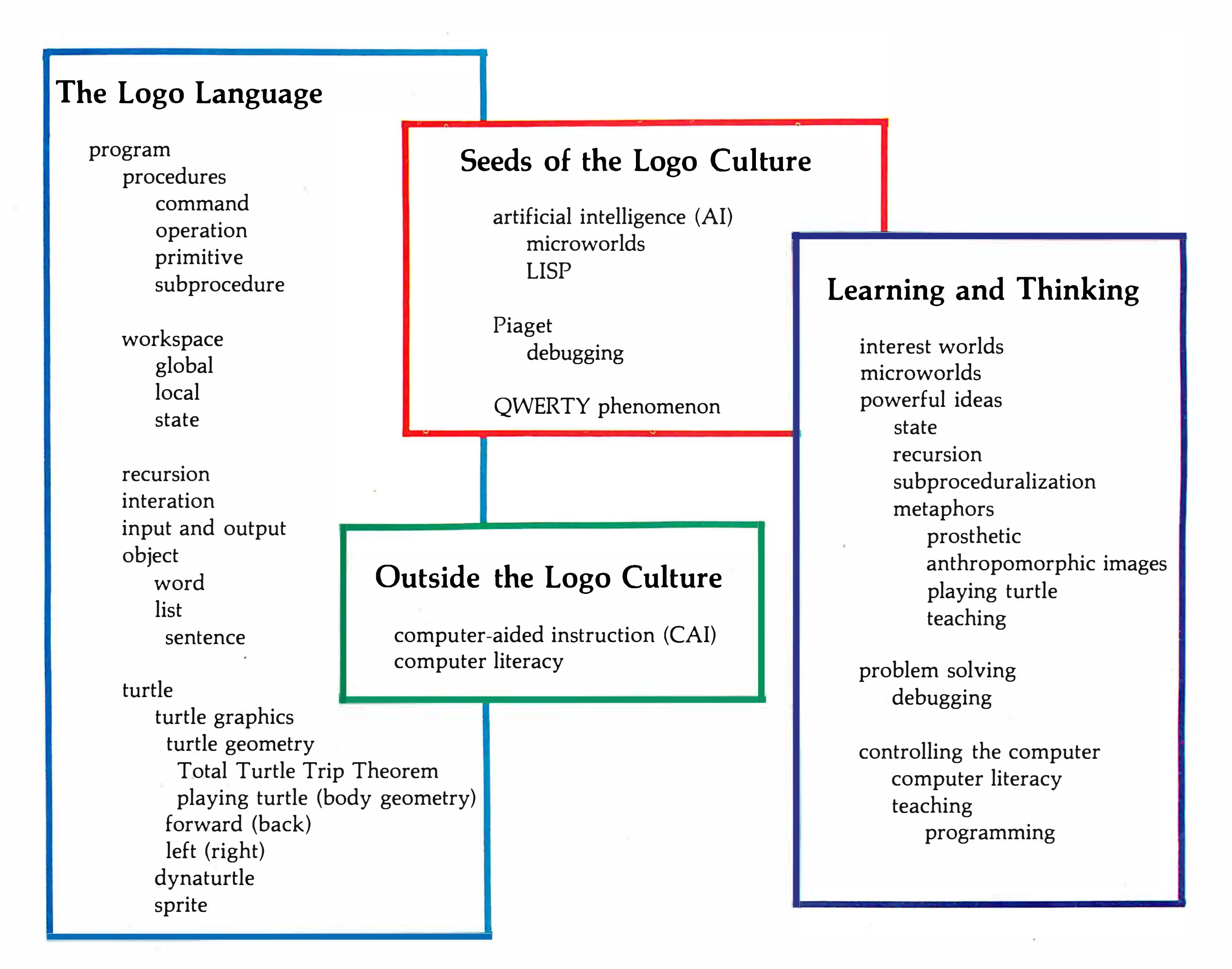
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Logo—A Cultural Glossary

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390 Lincoln Rd.
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For easy access, the terms in this glossary are arranged alphabetically, but this arrangement hides the complex interrelationships of the ideas in the definitions. The groupings on this page were developed to make obvious the relationships between important Logo concepts. You can use it as a map to guide you through the glossary.

The groupings do not represent a true tree structure because some of the terms appear under several different headings. The main concepts are organized into broad categories, with more detailed information listed in outline form under each main heading.

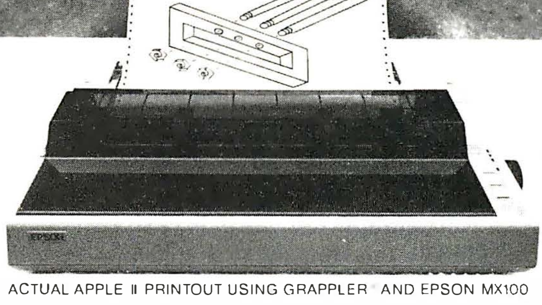


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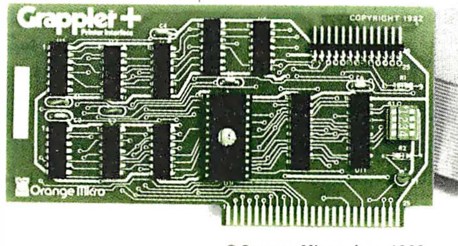
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This glossary is more cultural than technical partly because the learning philosophy behind Logo is more of a culture than a technique. The Logo technical vocabulary consists, for the most part, of familiar words adopted from general usage to refer to specific Logo metaphors, images, and ideas. Many of the terms and definitions presented here are derived from three books: Seymour Papert's *Mindstorms: Children, Computers, & Powerful Ideas* (New York: Basic Books, 1980); Harold Abelson and Andrea diSessa's *Turtle Geometry: The Computer as a Medium for Exploring Mathematics* (Cambridge, MA: MIT Press, 1981); and my own *Special Technology for Special Children* (Baltimore: University Park Press, 1979). Reference is also made to Brian Harvey's article "Why Logo?" on page 163 in this issue of BYTE.

anthropomorphic images: metaphors in which computers, computer procedures, and objects controlled by computers are thought of as if they were persons. "Anthropomorphic images facilitate the transfer of knowledge from familiar settings to new contexts. For example, the metaphor for what is usually called programming computers' is teaching the turtle a new word." (See Papert, page 59.) Thinking of the machines as (limited) people—and even modeling people's behavior through analogies to machine processes—does not involve treating people like machines. (On this latter point, see the entry on **computer-aided instruction**.)

About the Author

While working with the Logo Group at MIT, E. Paul Goldenberg pioneered in applications of Logo for education and rehabilitation of children with severe communication handicaps. His book Special Technology for Special Children *presents the philosophy, psychology, and technology behind this work and illustrates it with case histories. He is currently Assistant Professor of Rehabilitation Medicine at Tufts Medical School and will soon be director of the computer department at Lincoln-Sudbury Regional High School.*

artificial intelligence (AI): the branch of computer science from which Logo grew. The name of this science derives from its attempts to simulate, using machines, the behavior that is regarded as intelligent in people or animals. If this narrow view of the field was ever true, it no longer is. Cognitive psychology and artificial intelligence together are sometimes referred to as cognitive science. They study such disparate processes as natural-language understanding, visual perception, and knowledge acquisition. Good studies of human information processing frequently require both a careful study of how people perform tasks and serious attempts to build models based on a theory and observations to test the theory. The complexity of these models requires computer simulation.

command: a Logo procedure that performs in some particular way, but does not return a value to its calling procedure. It's analogous to a procedure in Pascal. See also **operation**.

computer-aided instruction (CAI): in the broadest sense, any educational endeavor that is aided by computers. In general, however, CAI means automated worksheets (drill and practice) or electronic tutors (frame-oriented CAI or automated programmed texts). This is very different from the Logo philosophy of using the computer not as the supplier or exerciser/tester of knowledge, but rather as a context within which to use thinking to solve problems of genuine interest.

Programmed learning explicitly models the human as a machine in that the student is being programmed by the computer. Logo learning sees the learner as the agent—actively constructing knowledge. The student takes the teacher's role—teaching the turtle a new word.

computer literacy: often seen as a general (and superficial) experience with computers. This concept is tied to a transitional stage in the spreading of computer technology. When computers were rarer and more specialized, computer literacy was not an issue (just as no one now worries about electron-microscope literacy). When computers become as common as cars, computer literacy will cease to be an issue.

Literacy has two conventional meanings. The first—being well-read and articulate in one's language—suggests fluency in a particular computer language. Programming is having the ability to express a novel idea in that language. Letting children be programmers, helping them to become fluent at expressing mathematical and logical ideas, is the Logo sense of a thoughtful literacy. (This idea, however, doesn't fit in with the image that the word "literacy" is generally used to convey, a skill that every child must learn in order to be able to cope. It's more like learning a foreign language: a valuable skill for those who choose to learn it, but not an absolute requirement for life or for employability.)

The other conventional meaning of literacy—having minimal reading skills—makes little sense in a society replete with computers. With many computer languages to choose from, what could be considered minimal communication skills? Teaching general familiarity with computers without providing an opportunity to develop good communication skill is a little like having a course teaching people the names of the features of a car without allowing them to learn to drive.

controlling the computer: the issue is one of locus of control. Whereas computers have conventionally been used in education to program the kids—in effect, to control their behavior—the Logo philosophy stresses kids programming computers. It is often said that teaching is the best way to learn. The computer is a highly responsive student and rigidly faithful to its teacher. For students who have had little sense of control in school, this, even apart from the content of the subject they are studying,

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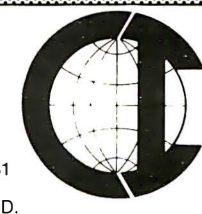
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is a valuable experience. (The importance of being in control is particularly apparent in the Logo work of students with special needs. For more, see *Special Technology for Special Children*.

debugging: improving the behavior of a program that does not do what you want it to. Logo emphasizes that programs that do not work as desired are merely unfinished, rather than bad finished products. This is in sharp contrast to many school situations in which a task is considered to be over when a particular time has come, rather than when it "works."

In school, a written composition tends to be graded as it stands, rather than debugged. (If the teacher does encourage a student to improve a paper, the effort involved can be prohibitive.) Logo teachers encourage students to love their bugs. If a turtle does not do what you wanted it to, chances are that it does something interesting anyway. The unwanted behavior may lead to new ideas more interesting than the original task. A bug can be neat! It can certainly teach you something . . . study it!

dynaturtle: a dynamic (rather than static) turtle. Whereas a static turtle has a fixed spatial position and heading, a dynaturtle may have a fixed velocity or acceleration. Whereas commands (state-change operators) to a static turtle specify a change in position (e.g., FORWARD 100) or heading (e.g., LEFT 90), a command to a velocity turtle specifies a change in velocity and has an analogy to force. Dynamic turtles can be a flexible laboratory tool for experimentation in physics and mathematics and, like their static cousins, for aesthetics as well.

FORWARD: Logo command to the turtle telling it to move forward in the direction it is heading. This state-change operator takes a single input that says how far (in turtle-steps) forward to move. For example, FORWARD 100 says move forward 100 units; FORWARD :SIDE + 10 says move forward the distance 10 + :SIDE (whatever value the variable :SIDE happens to have at the moment). The only other turtle-geometric state-change operator dealing with the turtle's position is called BACK. Neither of these change the turtle's heading. See also **LEFT**.

global: something pertaining to the entire environment being considered. Among variables, global variables are those that can be accessed and changed from any place in a program. Logo encourages the use of local variables—variables that belong to a particular procedure—because they make for more orderly and more debuggable programs.

Another kind of global reference is the Cartesian coordinate system. It is global in that each point is specified in relation to a standard referent (the origin). Points are not specified in relation to each other. For a discussion of the difficulties caused by such a global perspective for graphics representation, see the section of Brian Harvey's article "Why Logo?" on page 178 in this issue of BYTE. Logo's orientation is, in general, toward local references. See **local**.

input and output: within the Logo culture, we pay more attention to the inputs and outputs of procedures than to traditional issues of hardware. The input to a procedure is thought of as a message that the procedure needs in order to do its job. As an example, FORWARD needs an input telling it how far to move the turtle; PRINT needs to know what to print. Some procedures need more than one input message in order to know what to do. A procedure to draw arbitrary polygons, for example, needs two inputs, one telling it the size of its forward step, and the other telling it the angle to turn at each corner.

The output of a procedure is a message sent back to the procedure that called it. For example, SUM outputs a message that is the sum of its two inputs. A procedure that produces output (see **operation**) must send its message to a procedure expecting an input. (In this way, output and input are closely linked in Logo.) Hardware aspects of I/O are handled conveniently for the programmer so she can concentrate on the behavior of the conceptual building blocks (procedures) she is creating without wasting attention on the machine.

interest worlds: areas of special interest in which the computer can be a useful tool, servant, or laboratory. Art, music, geometry, physics, and language have all been extensively developed as interest worlds by various Logo investigators. See also **microworlds**.

iteration: telling the computer to execute something repeatedly. See **recursion**, which Logo favors as a control structure.

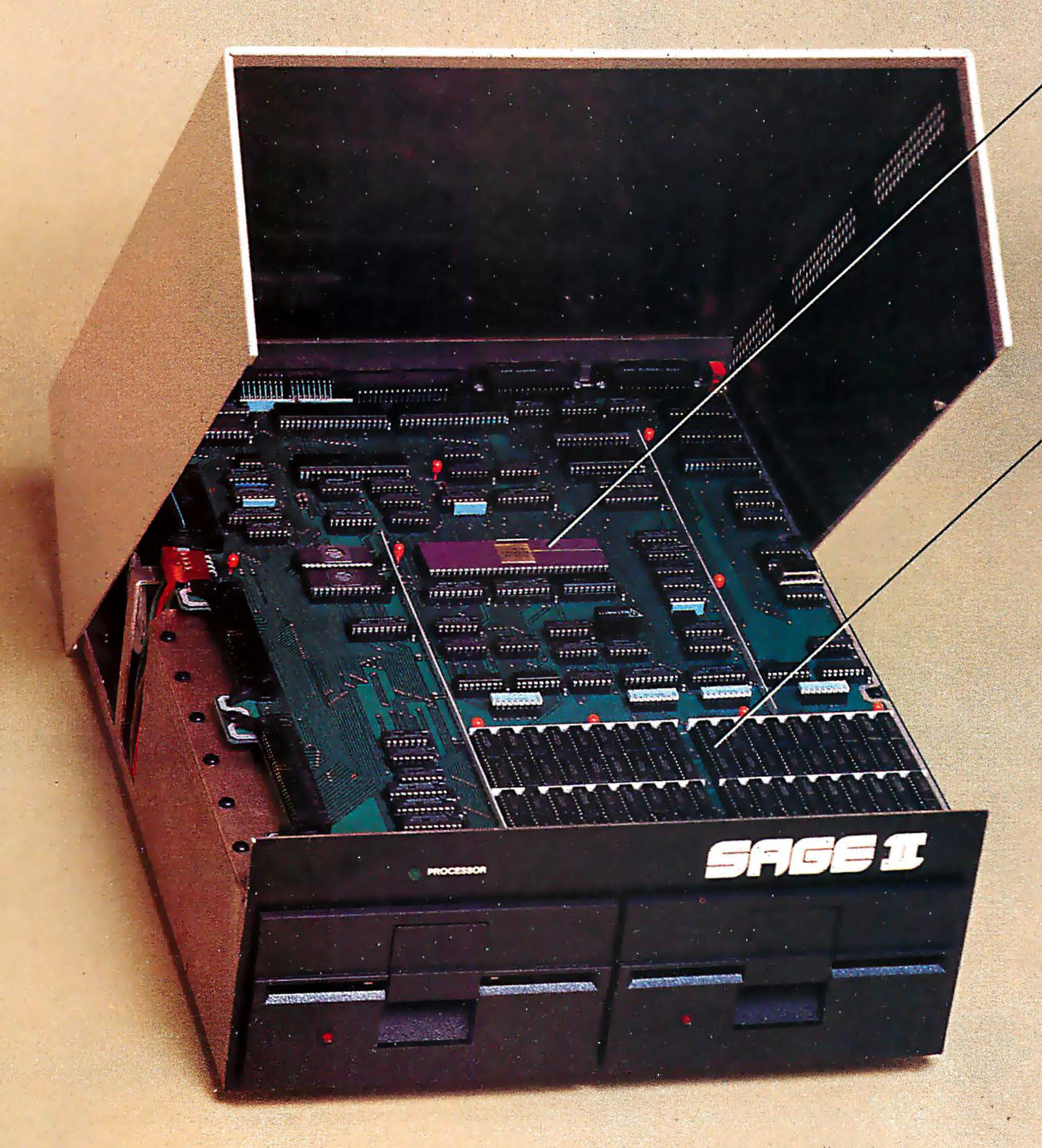
learning: the focus of the Logo environment. What one does for oneself. See **teaching**.

LEFT: Logo command to the turtle telling it to turn left while remaining in the same location. This state-change operator takes a single input that says how many degrees to turn. For example, LEFT :ANG says turn left :ANG degrees (whatever value the variable :ANG happens to have at the moment). The only other turtle-geometric state-change operator dealing with the turtle's heading is RIGHT. See also **FORWARD**.

LISP: acronym for LISt Processing. A programming language widely used in artificial-intelligence research, the basis for many of the ideas in Logo.

list: Logo's fundamental data structure. A list is an ordered sequence of arbitrary Logo objects (see **object**). Since its elements may be either words or other lists (which may themselves contain yet other lists, nested to any level), lists can be used to create very complex data structures. They can represent information trees (decision trees, binary trees, etc.) and unordered sets. Lists are sometimes used in Logo to accomplish the same purposes for which arrays might be used in other languages. (Logo also has other ways of providing access to information that is indexed numerically or with alpha-

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betic labels. Some Logo implementations have array-handling primitives.) The simplest elements of lists are words.

local: something that has meaning only in the specific context in which it is being used. A local variable is one whose name has a value only within the procedure in which it is defined. Most variables used in Logo are local. The turtle's perspective on its turtlemoves is also a strictly local one. It does not know where it is (with respect, say, to a globally defined origin). In the grand scheme of things, it doesn't need to know where it is. It only needs to know how to move with respect to itself. "The turtle can forget about the rest of the plane when drawing a circle and deal only with the small part of the plane that surrounds its current position.

"By contrast, $x^2 + y^2 = r^2$ relies on a large-scale, global coordinate system to define its properties. And defining a circle to be the set of points equidistant from some fixed point is just as global. . . . The turtle representation does not need to make reference to that 'faraway' special point, the center." (See Abelson and diSessa, page 14.) This local view of movement in space is not only easier to use for simple mathematical ideas, but lends itself quite beautifully to extensions into very fancy math; calculus and limits immediately come to mind. See **global**.

Logo: not an acronym. Derived from the Greek word for "word" or "thought." The name was coined by Wallace Feurzeig at Bolt Beranek and Newman Inc., one of the collaborators in the development of the language.

metaphor: Logo learning makes considerable use of metaphor and pays particular attention to which metaphors are chosen. Is a computer a tutor, a student, a pair of eyeglasses, or a screwdriver? Is a variable name the name by which we refer to a particular value, or the name of a box in which we find whatever we find? Are procedures little folks with specific jobs to do? Are robot turtles literate but literal-minded pets? It is not that Logo learners have particular metaphors that are different from those of others—some people find the little-people model of procedures useful, while others find it irritating—but that the use of metaphor is such a natural part of Logo learning.

microworlds: as used by Logophiles, a microworld is a well-defined, but limited, learning environment in which interesting things happen and in which there are important ideas to be learned. A microworld can have other microworlds within it. For example, within the microworld of turtle graphics, one can define a smaller microworld consisting of all the designs that can be drawn with a POLYSPI procedure. (See R. W. Lawler's "Designing Computer-Based Microworlds" on page 138 in this issue.)

The concept of microworlds is borrowed from artificial-intelligence research. It's very difficult to simulate intelligent behavior in general, but by restricting our attention to a very small area we can begin to find elements that can be modeled. Thus, the concept of microworlds is a useful source of interesting programming projects.

The most famous AI microworld is the blocks world, in which the computer controls a robot arm that can manipulate small blocks. You can tell the computer things like "Put the red block on top of the small green block," or ask questions like "Are any green blocks under a red block?" This is a microworld of the English language (among other things) in that it must understand the vocabulary, syntax, and semantics of sentences pertaining to the moving of blocks. It is also a microworld of structural stability, in that it must understand what physical maneuvers are possible with stackable blocks. One cannot, for example, realistically pick up the bottom block in a stack of eight without dropping others. Similarly, one can place a pyramidal block on a

cube, but not a cube on a pointy block.

object: the naturalness with which Logo passes data messages back and forth among procedures (see **input and output**), and the ubiquity of anthropomorphic images for those procedures, makes the metaphor of object manipulation very appealing for what tends to be called data processing elsewhere. Logo has two kinds of data objects, words and lists. (Some implementations also provide arrays.) Though procedures are generally known as the active elements in a workspace, they can also be manipulated (created, edited, destroyed, or passed back and forth) by other procedures. Therefore, Logo's procedures are also frequently referred to as objects, especially when one is referring to the contents of the workspace. Finally, "object" retains all of its conventional meanings in addition to the technical sense mentioned already. Thus, we speak of procedures as manipulating objects, whether the objects are words printed on the screen or turtles doing a dance on the floor.

operation: a Logo procedure that computes a value and returns that value to the calling procedure. (It is analogous to what Pascal calls a function.) The value can be any Logo object—a number, word, or list. See also **command**.

Piaget: Jean Piaget, one of the great thinkers of our time, realized the value of looking at a wrong answer and trying to understand it (see **debugging**). He was a keen observer of children and recognized that every learner (in particular, each infant and child) takes an active role in his or her own development. For each wrong answer a child came up with (e.g., the 4-year-old stating confidently that trees make the wind blow), he asked the question: Why *that particular* wrong answer? What is the *logic* in the child's thinking that leads to that kind of explanation?

In this sense, he saw these wrong answers not as random movements in the absence of the right answer, but as the result of bugs in a program that does give mostly the right answer. The frequent focus of attention on Piaget's stages is a bit of a red herring. Although he has described these stages discretely, it is their contents—the form that thinking takes at various developmental levels, the *logic* of it—and not the stages themselves, or the age at which they appear, that are the real importance of Piaget's theory.

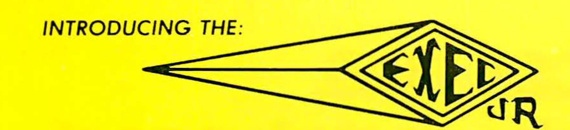
Evidence of the influence of Piagetian thinking (if not each of Piaget's specific notions about thinking) pervades the Logo culture. Our interest in debugging, the metaphor of objects, and the assimilation of computer technical ideas into familiar contexts (e.g., anthropomorphization or playing turtle) all reflect that influence.

playing turtle: pretending to be the turtle and walking through a turtle-graphics procedure as the turtle might see it. This process can make fairly difficult geometric constructions transparent to young children with little or no formal training in geometry. Playing turtle, though, refers as much to the thinking through of a procedure before programming it as to walking through an existing procedure.

By way of example, some 10-year-olds were trying to figure out how to teach the turtle to make a circle. I suggested they play turtle. They concluded that if all they could tell the turtle was to go FORWARD and to turn, it would have to go just a little bit forward, turn a little, go a little bit forward again, turn a little again, and so on. After one kid had made it around the circle (one of the instructions was "keep doing that until you get back to the beginning"), they were convinced they had the right idea. To help them with the details, I reminded them of the Total Turtle Trip Theorem and again encouraged them to play turtle. They began to reason out the details of how much to turn, how many times to repeat the process, and how big they wanted to make each step.

powerful ideas: Seymour Papert com-

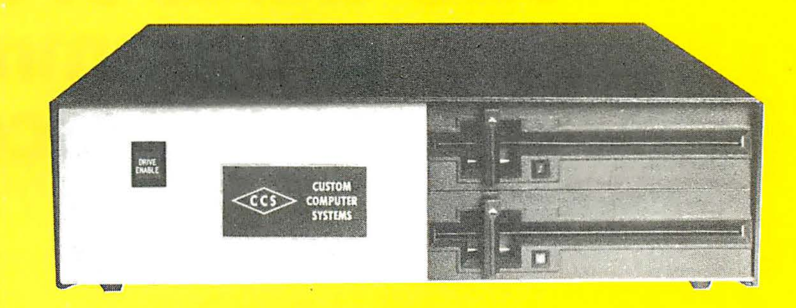
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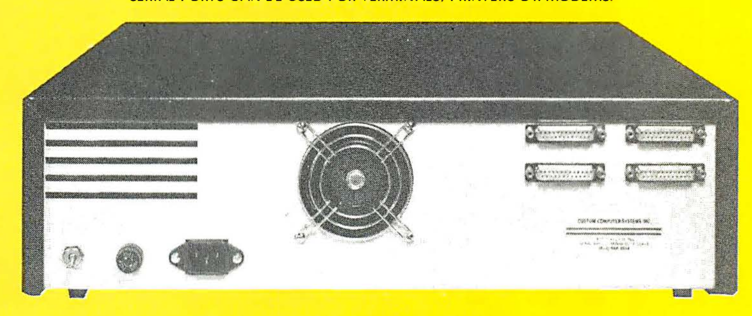
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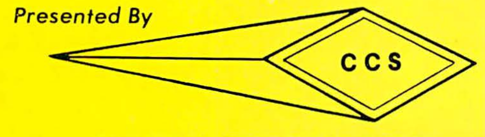
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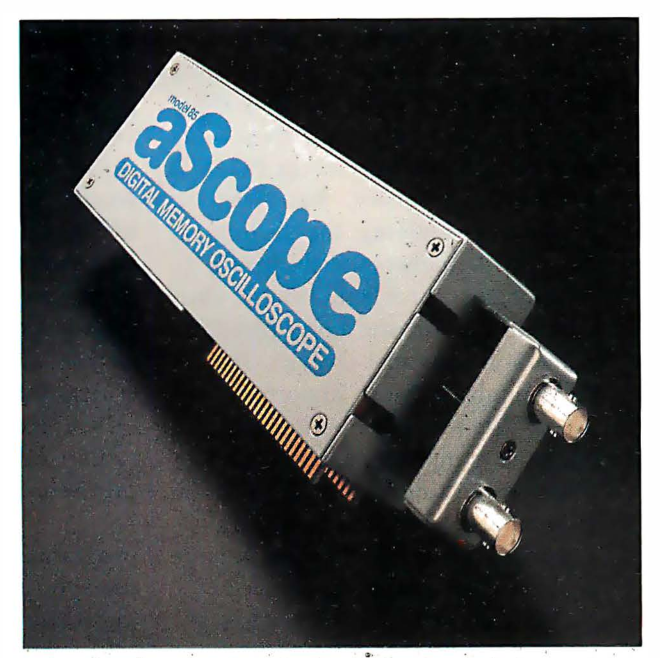


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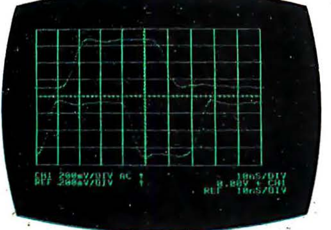
So we'll proceed with a few action recommendations designed to accommodate anyone from the casually curious to the virtually convinced.

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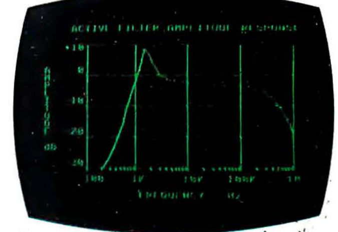
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A reference waveform loaded from disk into Channel 2 for comparison with active signal on Channel 1.



Cross-cursor indicates point where aScope™ digital voltmeter (DVM) is calculating waveform voltage for display at bottom of screen.



One example of a user-defined co-resident BASIC program; in this case designed to plot an amplitude response curve for an active filter.

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programmable oscilloscope with a controller when to a great extent the microcomputer circuitry and capabilities of one are already available in the other. So we didn't combine, we integrated. Making the aScope a peripheral part of the computer. Supplying only what was necessary to make the computer a high-performance instrument. An instrument capable of things until now assumed impossible for anywhere near its price.

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aScope is also equipped to deliver waveform voltage readings utilizing a cursor-controlled digital voltmeter. And to generate hard copies via an Epson MX-80™ or Silentype™ printer.

Space permitting, we could go on about the menu-driven commands and other user-sensitive features we've built into this have regarding aScope capabilities and applications.

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pares the Total Turtle Trip Theorem to "its Euclidean counterpart: (at least in the context of Logo computers), the Total Turtle Trip Theorem is more powerful: The child can actually use it. Second, it is more general: It applies to squares and curves as well as to triangles. Third, it is more intelligible: Its proof is easy to grasp. And it is more personal: You can 'walk it through,' and it is a model for the general habit of relating mathematics to personal knowledge." (See Papert, page 76.) An idea that can be used in a variety of personally meaningful contexts, that can be thought through, and that is a model for clear thinking is certainly powerful. Other powerful ideas are state, recursion, and subproceduralization.

primitives: the built-in procedures of Logo. Since Logo encourages programmers to build their own procedures as chunks of larger projects, it is useful to have a term to refer to the indivisible chunks that Logo provides initially.

problem solving: a skill that is at the core of Logo's "curriculum." Most traditional math instruction is about already-solved problems; the student memorizes someone else's techniques. Only recently have people understood that real mathematicians do something very different; they don't just study old problems, they solve new ones. Professor George Polya at Stanford University has been a pioneer in studying the techniques that good mathematicians bring to bear on new problems. Many ideas that are part of the Logo programming style parallel Polya's mathematical ideas. Most important, the use of procedures as building blocks for more complex procedures (as opposed to writing one huge program without a layered structure) parallels Polya's strategy of dividing a large problem into smaller pieces.

procedures: the conceptual building blocks of Logo programs. Logo users start with a vocabulary of primitive (built-in) procedures, and use them to teach Logo new vocabulary that can then be used in all the ways that primitives are used.

program: the Logo use of "program" is much more like the television use of it than of the usual computer use. A program is the whole show and may consist of a host of songs and dances, skits, acts, and routines. (But the word "routine" is not routinely used by Logophiles to mean a part of a computer program.) A person writes procedures. The top-level procedure runs a program that may be quite simple or may involve the use of several subprocedures. If it makes use of subprocedures, this top-level procedure may be referred to as a superprocedure.

programming: consider the following metaphors for programming: teaching turtle a new word; communicating with the turtle; translating from English to French or Logo; or being fluent enough in a language to express oneself easily.

prosthetic: one metaphor for the computer. As an artificial arm may help an amputee manipulate objects, so may an artificial piano player help one manipulate music. Because it is a versatile tool it can provide access to a large variety of inaccessible spaces and activities. The computer's use in musical composition and performance, graphics production (e.g., the special effects in a slew of recent television advertisements and in movies like *Star Wars*), and other areas are all extensions of human abilities—but extensions without which we are severely disabled in areas we now take for granted. It is merely a sociological and technological artifact that we regard as handicapped people who lack certain other abilities we take for granted. (For more on computers as aids to communication and autonomy for special education or rehabilitation, see *Special Technology for Special Children*.)

QWERTY phenomenon: Papert uses this term to refer to traditions that dig

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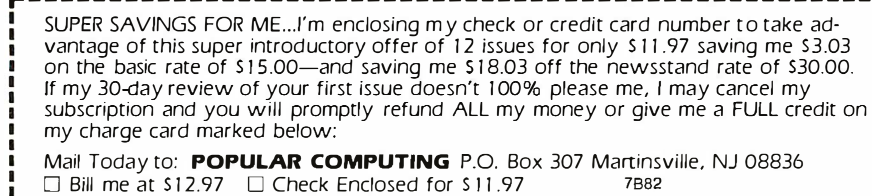
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themselves in after their original purpose, presumably a good one, has become obsolete. The name derives from the six top left-hand letters on a standard typewriter keyboard. This arrangement of keys was chosen to slow down a typist so that the early manual typewriters would not readily jam. Attempts to convert to a more optimal arrangement of keys have routinely failed as people were used to doing things the old way. So, too, much of the curriculum survives primarily because it is familiar and not because it makes much current sense.

recursion: a recursive definition defines a procedure or function in terms of itself. For example, a recursive definition of "factorial" states that 0!=1 and that n! = n*(n−1)! (See **recursion**.) A Logo program based on this definition might look like this:

```
TO FACTORIAL :N
IF :N = 0 OUTPUT 1
OUTPUT :N * FACTORIAL (:N - 1)
```

A nonrecursive definition might say something like:

n! = n*(n−1)*(n−2)*(n−3)*
...*3*2*1.

(Compare the structures by writing the latter in BASIC.) Both definitions and programs work, of course, but which definition one chooses affects how one programs. In the case of "factorial," both definitions are easy to implement, but sometimes recursion is the only way. For more on recursion, see the section of Brian Harvey's article on page 166 in this issue of BYTE.

sentence: in Logo, a sentence is a list of words. Logo provides tools to manipulate the words of a sentence. In most programming languages, one uses character strings instead of sentences; an English sentence becomes simply a bunch of symbols, some of which are letters and some of which are spaces. But those computer languages don't help the programmer divide this uniform character string into words. Logo's approach is an example of the microworld influence in programming.

sprite: animation of graphics has long been a high priority in Logo implementations, but only recently have small computers gained the power to handle animations well (except, of course, for animations written efficiently in assembly language). Sprites may be thought of as screen objects with a defined appearance (color, shape, size, etc.) and a velocity. Both of these can be changed according to the wishes of the programmer. They "live" on different layers of the screen, as if they are on plastic overlays. Thus, a sprite defined as a picture of an elephant may roam through a forest of trees, passing behind some and in front of others. The Logo programmer does not have to attend to the hiding of lines when one sprite is partially occluded by another—that is handled automatically. In this way, complex animations involving three-dimensional interactions of several screen objects can be as simple as drawing the objects and instructing each on how it should move.

state: the relevant properties of something. For example, the state of the turtle includes its position and the direction in which it's pointing, but doesn't include any of its past history (such as the distance it has traveled). The criterion of relevance here is that the turtle's future behavior, in response to some Logo program, depends only on its current state and not on its past. (Of course, the turtle's state does reflect where it has been, but tells only part of the history and not all of it.) The isolation of only the important aspects of a situation is a valuable debugging tool.

subprocedures: Logo encourages students to deal with large problems by dividing them into subprocedures. In a "long, featureless set of instructions it is hard to see and trap a bug. By working with small parts, however, bugs can be confined and more easily trapped, figured out." (See Papert,

page 102.) Logo's subprocedures are more than what one sees in carefully subroutinized BASIC. They become extensions to the language and can have meaningful names (see **powerful ideas**). For more on the distinction between subroutines and subprocedures, see the section of Brian Harvey's article on page 163 in this issue of BYTE.

teaching: what a person does to a computer. See **learning**.

Total Turtle Trip Theorem: when a turtle wanders over a path and ends up heading in the same direction as when it started, its total turning is an integer multiple of 360 degrees. Some special cases follow. If it wanders over a simple closed curve (a closed path that does not cross itself, like a polygon, a circle, or the outline of a pond), it turns through exactly 360 degrees. To figure out how much to turn at each point of a five-pointed star, play turtle (remember to end up heading the same way you started). How many full rotations do you make while walking over the star shape? (Two.) Therefore, you have turned 2*360 degrees in all. How much at each corner? (A fifth of that.) Repeating [FORWARD 100 LEFT 200] enough times makes another kind of star. How many points does it have? What about the star made by turning 80 degrees at each corner? See also **turtle geometry**.

turtle: (1) a computer-controlled robot that has position and heading, each of which can be changed independently of the other. It is significant that these two components of the turtle's state are independent. Cars and trucks (and their remote-control toy versions) do not have independent control of heading and motion. Their inability to make sharp corners (no matter how good the turning radius) limits their usefulness in artistic and mathematical realms. Also, because the interaction complicates thinking about their behavior, it is difficult to write programs to control them in any realms; (2) a graphic representation (typically, a pointy isosceles triangle) of such a physical robot; (3) a creature that lots of people love even though the beast rarely does anything in anyone's presence.

turtle geometry: a genuinely new mathematics based on turtle movements. It emphasizes transformations in local space rather than relationships to a fixed global referent. See **local**, **Total Turtle Trip Theorem**, and **playing turtle** in this glossary. For more about the mathematics at a college or advanced high school level, see Abelson and diSessa's book.

turtle graphics: the graphics you know and love—the graphics command system that has crept into several other computer languages (I've seen it in some Pascal implementations and even a version of BASIC) originated with Logo. See **FORWARD**, **Logo**, and **turtle**.

word: the simplest form in which Logo stores data, a word is an unbroken string of characters (typically alphanumerics, but capable of being constructed to contain any characters including spaces or control characters, when that is desired). Words can be concatenated into larger words, dissected into parts, and used as elements of lists. Numbers, single characters, and character strings are all treated as words by Logo.

workspace: a Logo workspace may be thought of quite concretely as if it were a kitchen, basement, or art-studio workspace: a place where one can set out one's materials and begin to work. The Logo workspace contains all the procedures and data objects the programmer is currently using, which can be saved in whole or in part on files for use at a later date. Retrieving the contents of a file places its contents into the workspace, as does defining a new procedure or data object. Pictures or text that are on the screen are not part of the computer's internal workspace any more than pictures drawn by a robot turtle on the floor are part of that workspace. (Nevertheless, many implementations of Logo make it possible to save screen graphics on a file and retrieve that file to the screen.)■

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Logo for the Apple II, the TI-99/4A, and the TRS-80 Color Computer

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Gregg Williams
Senior Editor

Of all the languages we have covered in our annual August language issues, Logo is the only one you could probably find in computer stores along with the corresponding issue of BYTE. Versions of APL, Pascal, LISP, and FORTH have become available in the time since those language issues were published (we're still waiting for Smalltalk), but Logo is available *now*. Better still, the versions of Logo available now are probably better implementations than were their counterparts when *they* came out.

In this article I will compare four versions of Logo: *TI Logo* for the Texas Instruments TI-99/4 and TI-99/4A and *Apple Logo*, *Krell Logo*, and *Terrapin Logo*, all for the Apple II and Apple II Plus computers. A fifth version of Logo, *Color Logo* from Radio Shack for the TRS-80 Color Computer, was released just as I finished writing this article. It is reviewed separately in the text box on page 247. For the sake of convenience throughout this article, TI-99/4A will also refer to the TI-99/4, and Apple II will refer to both that and the Apple II Plus. And because Terrapin and Krell Logos are basically the same implementation, I will usually refer to them both at the same time as Terrapin/Krell. I will review the products in alphabetical order.

At a Glance

Name
Apple Logo

Type
Programming language

Distributor
Apple Computer Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

Manufacturer
Logo Computer Systems Inc.
222 Brunswick Blvd.
Pointe Claire, Quebec
Canada H9R 1A6
(514) 694-2885

Price
$175

Authors
Jim Davis, Gary Drescher, Ed Hardebeck, Stephen Hain, Tom Polucci, Brian Silverman, and other members of the LCSI staff

Format
5¼-inch floppy disk

Language Used
6502 machine language

Computer Needed
Apple II or Apple II Plus with a 16K-byte memory card

Software Included
Two Logo disks (copy protected)

Documentation
Apple Logo: An Introduction to Programming through Turtle Graphics, 153 pages; Apple Logo: Reference Manual, 186 pages

Audience
Anyone interested in Logo

Common Features

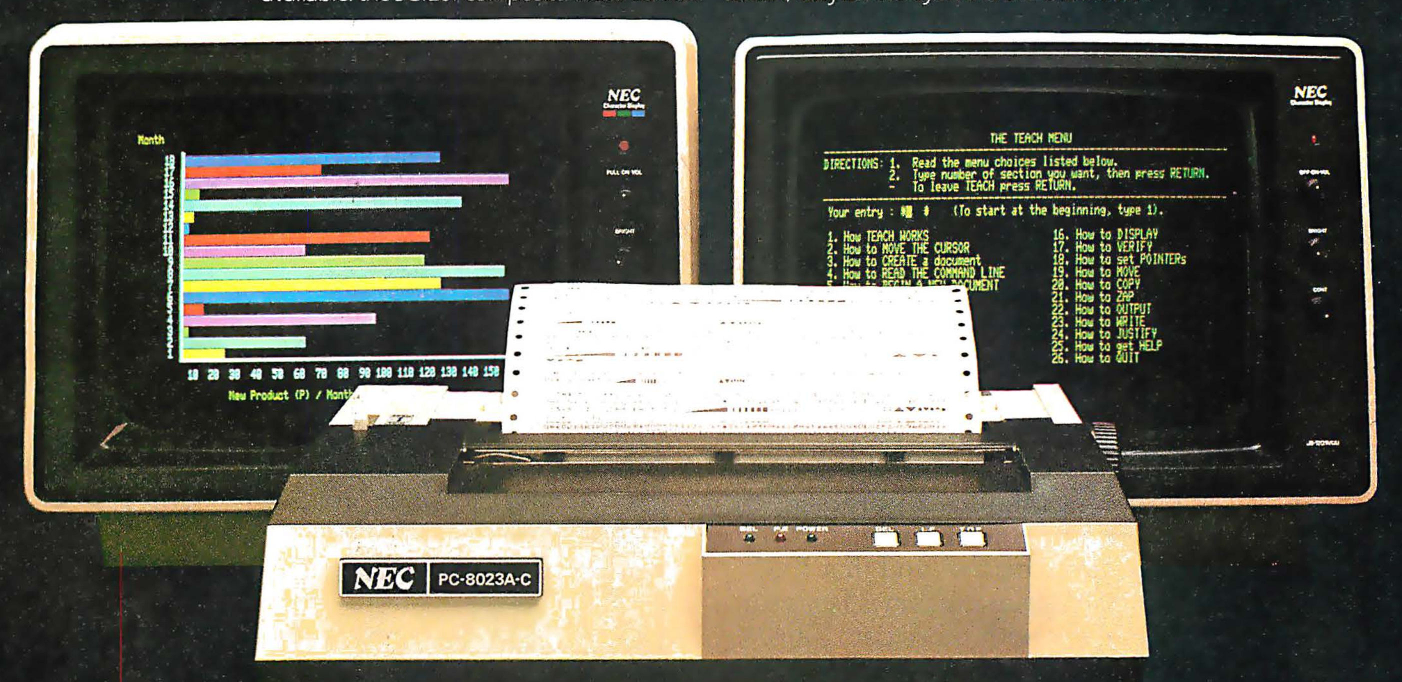
I won't presume to write any kind of tutorial on elementary Logo programming (for that, see the other Logo articles in this issue), but I thought I'd start this review by looking at some of the features common to Apple, Terrapin/Krell, and TI Logo.

The cornerstone of Logo is the concept of the *turtle*. The turtle is a triangular object on the video display that can be given simple commands (like FORWARD 50, PENUP, RIGHT 90). Since it carries a "pen" that can draw lines when in PENDOWN mode, commands given to the turtle result in line drawings on the video display.

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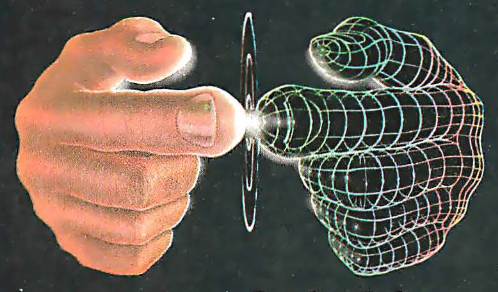


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Apple Logo and the P6A Problem

In an unusual combination of circumstances, Apple Logo may not work on your Apple. Here's why, and here's what you can do about it.

When the Apple Language System with Apple Pascal was first introduced, everyone had to replace the P5 and P6 ROMs (read-only memory chips) on their Apple disk-controller cards with the new P5A and P6A ROMs (this is what allows the Apple disk to store information in the denser 16-sector format). There was actually a bug in the P6A ROM so small that no software ran incorrectly because of it. Apple started supplying the corrected P6A and didn't worry about the few people who had the older P6A ROM. This was a reasonable thing to do since the change didn't make any difference, right?

Wrong. Some two years later, the company that did the copy-protection scheme for Apple Logo found that the protected Logo disk wouldn't boot on some Apples. It eventually discovered that the bug in the older P6A ROM was the culprit.

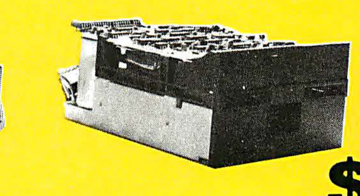
When Apple Computer Inc. was told, it decided to solve the problem by instructing all its authorized dealers to give, free of charge, a P6A ROM to anyone who can prove he has an Apple disk drive. (The easiest way to prove that is to take the disk-controller card in to the dealer.) Dealers will be reimbursed by Apple, so they should be glad to give you the P6A ROM even if you didn't buy your computer there. If you have any trouble doing this, contact Apple Computer Inc. at (408) 996-1010.

(Terrapin Inc. also sells an actual robot turtle that can be controlled from the Apple II and Terrapin Logo—it's a two-wheeled object about half the size of a basketball, and it can draw on large sheets of paper placed under it.)

Terrapin/Krell and Apple Logo use the Apple high-resolution graphics screen to display the turtle and its drawings. Both can draw in the six Apple II colors (black, white, green, violet, orange, and blue) and in a "color" called "reverse," which reverses the part of the high-resolution screen it passes over according to a fixed set of rules known to most Apple users. The Apple Logo turtle can also be given an erasing pen that draws in the color of the video-display background. Because the Apple II maintains separate text and graphics screens, you can switch between the two at any time with control keys that display text only, split text and graphics, and graphics only (the keys used are different for the two Apple Logos, but they perform the same function). An example of a program that uses turtle graphics is given in listing 1; the drawing it produces is shown in photo 1.

The TI turtle is, in contrast, rather limited in that its implementation restricts the amount of drawing it can do before it "runs out of ink." The TI-99/4A does not have a graphics mode







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Listing 1: *A set of Logo procedures using turtle graphics. The main procedure, called* 4.BUGS, *traces a figure from recreational mathematics: four bugs that, starting in the corners of a square, move in the direction of the bug clockwise to them (as illustrated on our cover). This version is in Apple Logo. The resulting drawing is shown in photo 1.*

```
TO MOVEBUG :N
;  []
;  [THIS MOVES BUG IN TOWARD THE NEXT BUG CLOCKWISE]
;  [FROM BUG N. IT ALSO DRAWS A LINE FROM]
;  [THE BUG'S STARTING CORNER TO ITS CURRENT]
;  [POSITION TO ADD COLOR TO THE DRAWING]
;  []
(LOCAL "BUG.N "BUG.M "CORNER.N)
MAKE "BUG.N (WORD "BUG :N)
SETPC :N + 1
;  []
;  [PUT TURTLE TO CURRENT BUG POSITION]
PENUP
SETPOS LIST (GPROP :BUG.N "XVAL) (GPROP :BUG.N "YVAL)
PENDOWN
;  []
;  [POINT TURTLE TOWARD NEXT BUG'S PRESENT POSITION]
MAKE "M (:N + 1)
IF :M > 4 [MAKE "M 1]
MAKE "BUG.M (WORD "BUG :M)
SETHEADING TOWARDS LIST (GPROP :BUG.M "XVAL) (GPROP :BUG.M "YVAL)
;  []
;  [MOVE TURTLE AND RECORD NEW POSITION AS]
;  [BELONGING TO BUG N]
FORWARD :LEN ; [LEN IS A GLOBAL VARIABLE]
PPROP :BUG.N "XVAL XCOR
PPROP :BUG.N "YVAL YCOR
;  []
;  [MOVE TURTLE TO STARTING CORNER, DRAWING LINE]
MAKE "CORNER.N (WORD "CORNER :N)
SETPOS LIST (GPROP :CORNER.N "XVAL) (GPROP :CORNER.N "YVAL)
END

TO BIGSQ :SZ
;  []
;  [THIS DRAWS A SQUARE OF LENGTH :SZ WITH THE]
;  [CURRENT TURTLE POSITION AS CENTER. AT THE
;  [END, THE TURTLE'S POSITION IS UNCHANGED,]
;  [BUT THE PEN IS DOWN]
;  []
PENUP
HALFSQ :SZ / 2
PENDOWN
REPEAT 4 [FORWARD :SZ RIGHT 90]
PENUP
HALFSQ :SZ / 2
PENDOWN
;  []
END

TO HALFSQ :SZ
;  []
;  [THIS DRAWS TWO SIDES OF A SQUARE -- THE PEN]
;  [MAY BE UP OR DOWN]
;  []
REPEAT 2 [FORWARD :SZ RIGHT 90]
;  []
END
```

Listing 1 continued on page 238

Software Breakthrough...

NEW

NEW *QUIKPRO + PLUS* WRITES PROGRAMS FOR YOU IN MINUTES ON *YOUR* Micro

Technical Review
by Wayne Hepburn

QUIKPRO + PLUS is a new breakthrough in software for microcomputers from ICR-FutureSoft.

Until now, whenever you wanted a new separate program in BASIC (Microsoft Basic/MBasic/Basic 80/Oasis Basic), you had to spend a lot of dollars for it, or a lot of hours creating it (if you have the know-how). That's all in the past now.

Anybody who can turn on a computer can write a program, quickly, with this new *Quikpro + Plus* software which generates programs for you. *Quikpro + Plus* is the invention of Joseph Tamargo of Florida. His brilliant approach to program writing allows you to tap the real power and speed of your microcomputer, and it is about time this happened.

I interviewed him to find out more about *Quikpro + Plus* and pass this valuable information to you. He told me "The best part of this software is that it gives you a separate custom program every time you use it. The resulting program is produced, error-free, in BASIC (Microsoft Basic/MBasic/Basic 80/Oasis Basic, as appropriate to your system) for you by *Quikpro + Plus.* What's more, you can list your new program, look at it, see what makes it tick, and modify it as you wish."

You can also, customize, enhance, alter, and even copy the programs you create with *Quikpro + Plus.* This is because programs created by *Quikpro + Plus* are structured, easy to follow, and include many REMARKS statements right in the program listing. I don't know of any other software with the flexibility and ease of use I found in *Quikpro + Plus.*

HUNDREDS OF APPLICATIONS...

For Education, Business, Hobby, Home, Science, Personal, etc. a partial list includes programs like these: Financial Forecasting, Expense Planning, Data Access and Retrieval, Modeling, Record Keeping of all kinds, Statistical Data Banks, and much, much more. *Quikpro + Plus* cuts the time it takes to generate a new custom program down to a few minutes. That's true. I saw a letter from a user who created a separate program in Basic within fifteen minutes after reading the clear, simple, complete Documentation & Operating Manual for *Quikpro + Plus.* The software will generate File Handling and Data Entry Programs in a file format, drawn right on the screen by user. Programs created by *Quikpro + Plus* produce standard ASCII Data Files allowing data to be easily accessed by other programs, other micro's, and even main frames.

HOW IT WORKS...

The operation of *Quikpro + Plus* is simple and easy. On your screen you answer questions which appear in plain English. The answers generate error-free Filing & Data Entry Programs for you...instantly. This completely eliminates the tedious and time consuming development you normally go through to write a program. Since the instructions are right on the screen you don't need any programming skills to operate *Quikpro + Plus.* Quickly, you get a fully independent new program ready to run on your system. After you create the new program you can remove *Quikpro + Plus* and stick it on the shelf until the next time you create a custom program.

PRINTS REPORTS & MANUALS...

There is a full report printing capability put into your new separate program by *Quikpro + Plus.* You can even print out in formats different from the File Format you used without altering the Record Data. Or you can selectively print portions of Files or selected fields from selected Records. Just about anything you want can be reported out from the Data Base associated with the new custom program you wrote.

PERFORMS CALCULATIONS...

You can perform all manner of computations among various fields in each record. You can selectively calculate and print resulting data only, or Data Base and results, or alter Records by calculation results, and so forth. The possibilities seem unlimited. And keep in mind that the power and features I am talking about end up in the separate new custom program *Quikpro + Plus* writes for you.

This software is ready to ship immediately and you can start writing programs the day you get in. In fact, ICR-FutureSoft guarantees your satisfaction or you can return it for a full refund in ten days after delivery. How's that for confidence? Mr. Tamargo said "There isn't any risk to us...our product *works* like it's supposed to work and users are very well satisfied. We are glad to guarantee satisfaction."

You get *Quikpro + Plus* by mail or phone directly from ICR-FutureSoft. Just write them, or call their Toll-Free phones and specify your model and version requirements from the list that follows:

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Operators cannot give technical help, accept orders only. Technical support call 1-904-269-1918.

Software Dealers can handle this software. Contact ICR-FutureSoft Customer Service at 1-904-269-1918 or write.

Listing 1 continued:

```
TO ADDPROPS :N :LIST
;  []
;  [THIS SETS UP THE WORDS BUG1 THROUGH BUG4]
;  [AND CORNER1 THROUGH CORNER4 WITH TWO]
;  [PROPERTIES EACH -- XVAL AND YVAL]
;  []
LOCAL "NAME1
LOCAL "NAME2
MAKE "NAME1 WORD "BUG :N
MAKE "NAME2 WORD "CORNER :N
PPROP :NAME1 "XVAL FIRST :LIST
PPROP :NAME2 "XVAL FIRST :LIST
PPROP :NAME1 "YVAL LAST :LIST
PPROP :NAME2 "YVAL LAST :LIST
;  []
END

TO; :N
END

TO SETPROPS
;  []
;  [FILL PROPERTY LISTS OF BUG1 - BUG4, CORNER1 - CORNER4]
ADDPROPS 1 LIST ( - 1 * :BIGUNIT) :BIGUNIT
ADDPROPS 2 LIST :BIGUNIT :BIGUNIT
ADDPROPS 3 LIST :BIGUNIT ( - 1 * :BIGUNIT)
ADDPROPS 4 LIST ( - 1 * :BIGUNIT) ( - 1 * :BIGUNIT)
;  []
END

TO 4.BUGS :LEN :TIMES
;  []
;  [THIS DRAWS THE CLASSIC SPIRAL CREATED BY]
;  [THE MOTION OF 4 BUGS, EACH STARTING AT ONE CORNER]
;  [OF A SQUARE AND FOLLOWING THE BUG CLOCKWISE]
;  [TO IT]
;  []
FULLSCREEN
HIDETURTLE
MAKE "BIGUNIT 100
BIGSQ (2 * :BIGUNIT)
;  []
SETPROPS
REPEAT :TIMES [MOVEBUG 1 MOVEBUG 2 MOVEBUG 3 MOVEBUG 4]
END
```

of video display, but it does have redefinable characters called *tiles* (more on them later). The lines drawn by the turtle are actually redefined tiles. Because only 192 of the 256 tiles are available for redefinition (64 store the TI-99/4A character set) and there are far more than 192 characters on the graphics part of the video display, a design can easily cover more tiles than are available. The limitation of the TI turtle is offset by the availability of colorful *sprites* on the TI-99/4A computer. All three Logos have a full complement of turtle commands; see reference list on page 280 for details.

Another traditional feature of Logo is a set of list-manipulating words. Although most of the publicity about Logo emphasizes its graphics and its suitability for education, Logo is also a fairly powerful list-manipulation language with distinct similarities to LISP (the granddaddy of artificial-intelligence languages). As an example, listing 2 shows a set of Logo procedures that sorts a list of words. Apple Logo and Terrapin/Krell Logo are roughly equal in their list-processing abilities, but TI Logo has some definite deficiencies; these will be discussed in a later section.

All five Logos also have some number-processing capabilities. TI Logo

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For instance, if you accidentally type "foreword," instead of forward, Apple Logo responds with "I don't know how to foreword."

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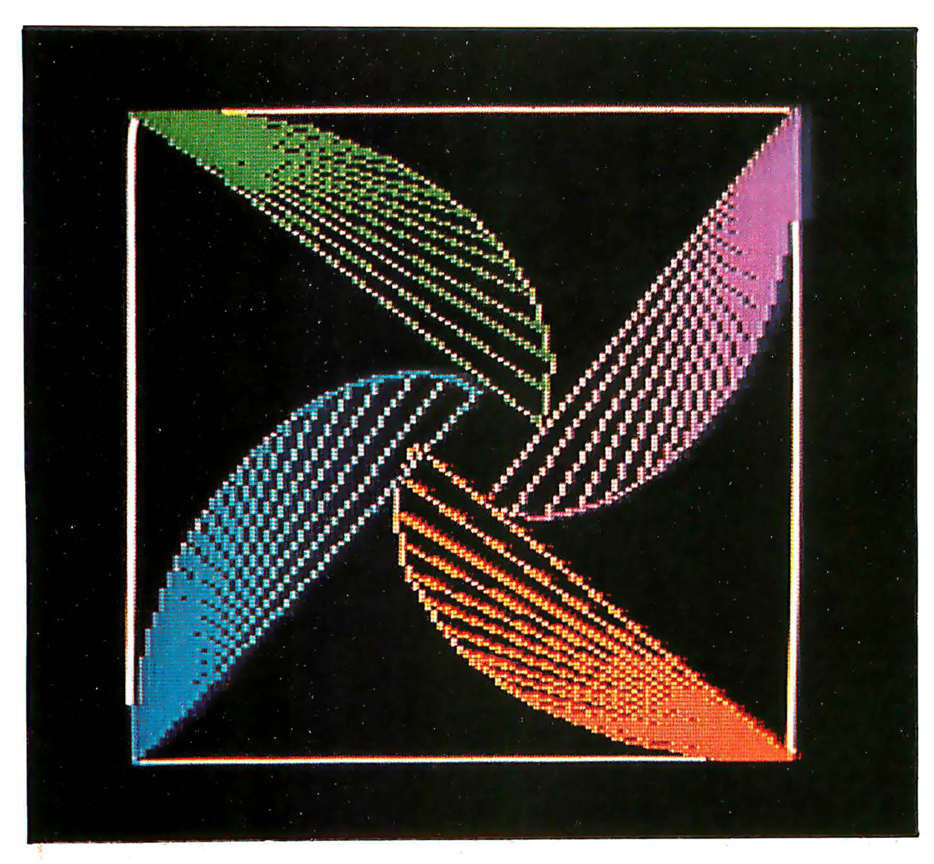


Photo 1: *A drawing made using turtle graphics and an Apple II computer. The procedure, called* 4.BUGS, *is given in listing 1. Each curved line is the actual path of the bug; the straight lines to the corner were drawn to add color to the photo.*

At a Glance

Name
Krell Logo

Type
Programming language

Manufacturer
Krell Software Corporation
1320 Stony Brook Rd.
Stony Brook, NY 11790
(516) 751-5139

Price
$149.95

Authors
Leigh Klotz Jr., Patrick Sobalvarro, and Stephen Hain

Format
5¼-inch floppy disk

Language Used
6502 machine language

Computer Needed
Apple II or Apple II Plus with 16K-byte memory card (will not work on Apple III)

Software Included
Two copies of MIT Logo (copy protected), Utilities Disk (with utilities from MIT and Krell), Alice in Logoland disk

Documentation
Logo for the Apple II: Technical Manual, by Harold Abelson and Leigh Klotz Jr., 57 pages; poster-sized summary sheet for Krell Logo; Logo for the Apple II, by Harold Abelson, 228 pages; Alice in Logoland Primer*; 1-year (5-issue) subscription to The Logo and Educational Computing Journal*; Teacher's Manual*

Audience
Anyone interested in Logo

* refers to materials stated as part of the package but not seen by the reviewer; Krell says it will send all missing materials to earlier purchasers of Krell Logo.

and Radio Shack Color Logo are limited to integers between −32,768 and 32,767, while Apple Logo and Terrapin/Krell Logo use both integers and floating-point numbers. The Apple-based Logos are as useful for arithmetic computation as any BASIC. In addition to the four basic

TI Logo and Radio Shack Color Logo are both limited to integer arithmetic, while Apple Logo and Terrapin/Krell Logo use floating-point arithmetic.

arithmetic operators, the Apple-based versions offer the sine, cosine, and arctangent functions, rounding and truncating (to integer) functions, and a square root function.

All five Logos have editors that allow Logo procedures to be created and edited. The Apple Logo and Terrapin/Krell Logo editors are very similar, although I like the Terrapin/Krell version a little more because of a slightly more convenient arrangement of function keys. Apple Logo gives you a simple line-at-a-time, no-editing way to type in procedures; this is probably intended for young children who might get confused by the power of the regular editor. (Terrapin/Krell Logo offers a similar procedure on its Utility Disk.) The TI and Radio Shack versions have less sophisticated editors. All the editors except the Radio Shack one work in a way that is somewhat annoying to experienced users. For example, you are always in a kind of insert mode—when you type characters, they are inserted at the cursor location and all other characters on that line are moved to the right. You must use a specific keystroke to delete a character or a line. In any case, the editors in each Logo are easy to learn and are not, in themselves, worthy of more discussion here.

(One additional editing feature of the Apple-based Logos is the ability to reproduce the last line typed in when not in the editor. The line ap-

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Listing 2: *A set of Logo procedures that will sort a list of words. This version is written in Terrapin/Krell Logo and is used as a benchmark. The empty brackets on several lines were placed there automatically by the Terrapin/Krell Logo editor. Due to space limitations, the slightly different versions that run on the Apple and TI-99/4 will not be given here.*

```
TO STR.GR.THAN :FIRST :SECOND
  ;  []
  ;  (READ THIS NAME AS "STRING-GREATER-THAN")
  ;  []
  ;  THIS RETURNS A TRUE OR FALSE VALUE DEPENDING
  ;  ON WHICH OF TWO WORDS, :FIRST OR :SECOND
  ;  ALPHABETICALLY PRECEDES THE OTHER
  ;  []
  IF :FIRST = :SECOND OUTPUT "FALSE
  IF :FIRST = " OUTPUT "FALSE
  IF :SECOND = " OUTPUT "TRUE
  MAKE "CHAR1 FIRST :FIRST
  MAKE "CHAR2 FIRST :SECOND
  IF ASCII :CHAR1 > ASCII :CHAR2 OUTPUT "TRUE
  IF ASCII :CHAR1 < ASCII :CHAR2 OUTPUT "FALSE
  OUTPUT STR.GR.THAN BUTFIRST :FIRST BUTFIRST :SECOND
END

TO INSERT :WORD :LIST
  ;  []
  ;  THIS INSERTS :WORD ALPHABETICALLY INTO
  ;  AN ALREADY SORTED :LIST; THIS RETURNS
  ;  A NEW LIST THAT CONTAINS ALL OF :WORD
  ;  AND :LIST, NEITHER OF WHICH IS CHANGED.
  ;  []
  IF NOT STR.GR.THAN :WORD FIRST :LIST THEN OUTPUT FPUT :WORD :LIST
  IF STR.GR.THAN :WORD LAST :LIST THEN OUTPUT LPUT :WORD :LIST
  OUTPUT FPUT FIRST :LIST INSERT :WORD BUTFIRST :LIST
END

TO SORT :LIST
  ;  []
  ;  THIS RETURNS A SORTED LIST THAT HAS THE
  ;  SAME CONTENTS AS THE UNSORTED :LIST
  ;  []
  IF :LIST = [] OUTPUT []
  TEST BUTFIRST :LIST = []
  IFTRUE OUTPUT :LIST
  IFFALSE OUTPUT INSERT FIRST :LIST SORT BUTFIRST :LIST
END
```

pears on the screen and can then be modified with a handful of keys that are used for editing outside the Logo editor. This is very useful when the same thing or slightly different versions of it need to be executed repeatedly.)

One feature common to all the Logo implementations covered here has to do with Logo source code. Although Logo is supposed to make using the computer as easy as possible, none of the implementations discussed here allows Logo procedures to be typed in (or printed out) with the indentations and statement groupings that make a structured language more readable. For example, a REPEAT statement with several statements in the body of the repeat loop must put all the statements on one line. They cannot be placed one statement per line (as can be done in Pascal, for example) because these implementations use a carriage return to denote the end of a completed Logo command. This is an unfortunate fact we will have to live with for now; perhaps later versions of Logo will remedy the situation.

Two final notes concern the Apple-based versions of Logo. Because the language uses the 16K-byte memory card (the Apple Language Card or its equivalent), neither Apple Logo nor Terrapin/Krell Logo will run on an Apple III under Apple II emulation mode. In addition, Apple Logo may not load on a few Apple IIs. See the text box Apple Logo and the P6A Problem on page 234 for more details.

Apple Logo

Apple Logo's greatest strength is its advanced programming commands. *Package-related commands* allow you to group together selected procedures and variables and manipulate them by a given name; among other things, the package of items can be saved, erased, or hidden from view (or *buried*) in Logo. For example:

```
PACKAGE "PKG1 [PROC1 PROC2
  PROC3]
```

defines the package PKG1 to be the three procedures named above. You can then save just these items to a disk file named GWPKG1 with:

```
SAVE "GWPKG1 "PKG1
```

You can erase all the above items from the workspace with:

```
ERALL "PKG1
```

In addition, you can hide them from view with:

```
BURY "PKG1
```

After they are buried, the procedures are available for use, but they do not show up in any list of the workspace contents and they cannot be erased accidentally. The availability of packages makes workspace manipulation much easier (especially when you want to save, delete, or otherwise manipulate only part of the workspace), and the BURY feature allows you to customize the Logo workspace for a particular application and "lock" those features into Logo where they cannot be seen or altered by the nontechnical user.

(Another Apple Logo feature, the STARTUP file, allows you to create a

Text continued on page 250

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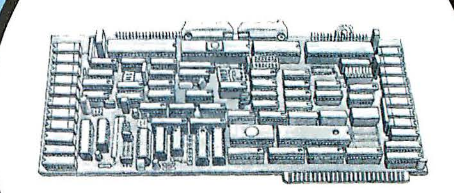
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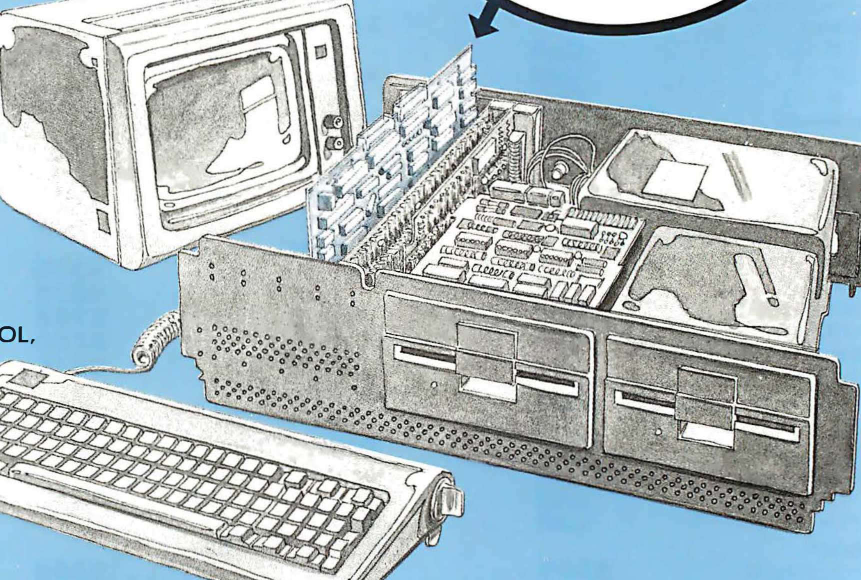
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Digital Equipment PDP-10	Mainframe	TOPS-10	BASIC (I)	65
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*C = Compiler; I = Interpreter. Times (except for Seattle Computer) taken from August 1981 issue of Interface Age.

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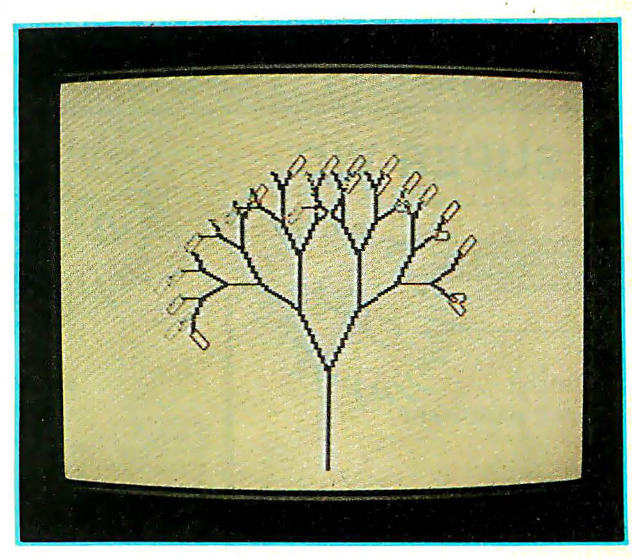
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Radio Shack Color Logo



A spiral drawn with Color Logo turtle graphics. Note that text and graphics can be mixed on the same screen. The oblong object at the end of the spiral trail is the Color Logo turtle.



Multiple turtles in Color Logo. Here, multiple turtles are simultaneously drawing the branches of a tree shape. (Some turtle shapes are smeared because they were in motion when the photo was taken.)

As this review was going to press, we received a preliminary version of Color Logo for the TRS-80 Color Computer. Although it would be unwise to do an in-depth review of a product before it is entirely finished, I will give you an overview of the product in its current form. (The language itself is finished, but the authors, Larry Kheriaty and George Gerhold of Micro Pi, are changing it where possible in response to the reactions of people who are critiquing it.)

Two factors influence the structure of Color Logo, which is radically different from the other Logos being reviewed here. The first factor is the absence of any connection to MIT, which had a direct hand in the other Logos. The second factor is the limited memory size of the TRS-80 Color Computer—it has a maximum of 32K bytes, which must accommodate both the Logo language and a usable workspace. (The version that we received is on a 5¼-inch floppy disk. The language will also be available on cassette and ROM cartridge. Since the cartridge version does not occupy any of the memory space, it will give Color Logo a larger workspace than is otherwise possible. The cartridge version will run on either a 16K-byte or a 32K-byte machine, but the disk and cassette versions require a 32K-byte machine.)

Because of the influences mentioned above, Color Logo is quite different from the other Logos reviewed here. It is intended for use by children, which is reflected in its limitation to turtle graphics. In other words, Color Logo supports turtle graphics (more on this later) but does not include any string- or list-manipulating words. In fact, all you can do outside turtle graphics is print a character string or number at the current location of the turtle.

Color Logo is radically different from the other Logos.

Color Logo has four modes: break, doodle, edit, and run. Break mode is a "central" mode from which you read and save files and go to the edit and run modes; all modes return to the break mode when the red Break button is pressed. All Logo statements and procedures are run from the run mode, through which turtle graphics appear (see above left photo). Edit mode allows you to create or change all the procedures in the workspace (all the procedures are in one workspace). Doodle mode, entered from run mode with a name that later becomes the name of the pattern about to be drawn, allows younger children to create turtle graphics with predefined one-key commands (Color Logo provides a keyboard overlay that identifies the keys). When doodle mode is exited, the pattern can be redrawn in run mode by executing the name given earlier.

The turtle graphics of Color Logo are on a 192 by 256 grid, although the actual resolution of the graphics is 192 by 128. The turtle and background can be one of four colors, and you can choose one of two 4-color sets (you cannot, however, mix the sets). This seems to be equivalent to medium-resolution graphics PMODE 3 in TRS-80 Color Computer Extended BASIC.

The most interesting feature of Color Logo is its ability to create multiple (up to 255) turtles and have them send messages to each other (see above right photo). A new turtle is created by a HATCH *command and then given an identification number, a procedure name to start executing, and an optional list of parameters to the procedure. The newly created turtle has the same shape, heading, and location as the turtle that created it, and it exists until the procedure calling it finishes or until a*

Continued on page 250



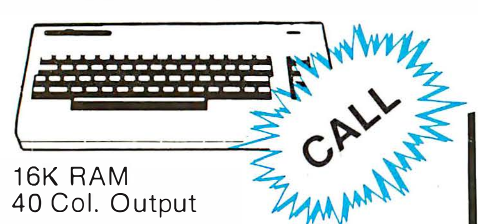


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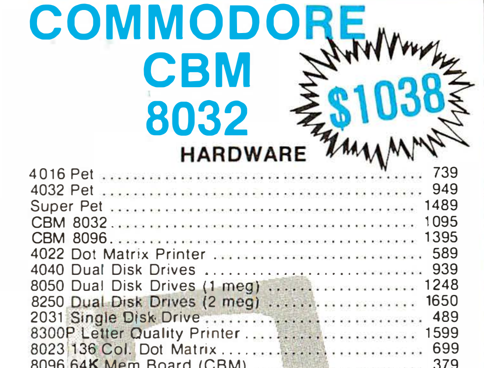
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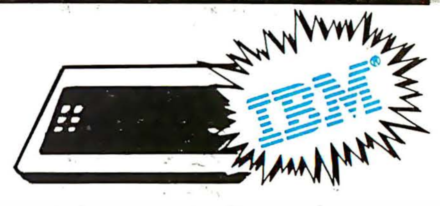
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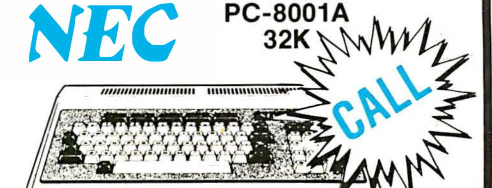
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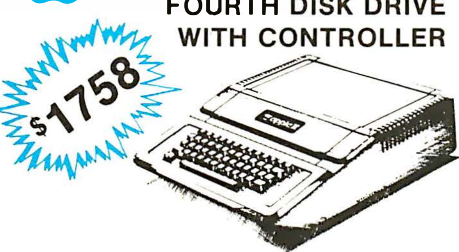
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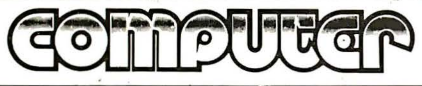
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At a Glance

Name
TRS-80 Color Logo

Type
Programming language

Manufacturer
Radio Shack, Education Division
400 Atrium, One Tandy Center
Fort Worth, TX 76102
(817) 390-3302

Price
Disk version, $99
Program pack version (not yet available)

Authors
George Gerhold and Larry Kheriaty

Format
Disk (available third quarter, 1982)
Program pack (read-only memory cartridge, available January, 1983)

Language Used
6809 assembly language

Computer Needed
Disk version, TRS-80 Color Computer with 32K-byte memory and disk drive
Program pack version, TRS-80 Color Computer with 16K-byte memory

Software Included
Disk version: one floppy disk containing the Color Logo language
one disk with sample programs

Documentation
Language reference manual and teacher's guide

Audience
Elementary school children, with some application to upper grades

VANISH *statement is called with its number. Color Logo processes one statement from each turtle, then repeats the process, thus giving the illusion that all the turtles are executing their programs simultaneously. Turtles can send and receive "mail," but the mail is limited to a single integer value between −32,768 and 32,767. Radio Shack claims in a press release that, with Color Logo, "Anyone from the preschool child to the computer scientist can investigate the principles of structured thinking (and programming), multitasking, interprocess communications, modular programming, parameter passing, local and global variables, and looping and recursion." Although about half of the above subjects can be taught with the language, I think that some of the claims are extravagant for a Logo that can only pass single-integer "messages."*

The disk version of Color Logo saves a maximum of 16 Logo workspaces, each of which is referred to by a letter from A to P. While this seems quite simplistic to most of us, it is exactly right for its intended audience, young children. I assume that the cartridge and cassette versions will use a similar mechanism.

Two more Color Logo features deserve mention. One is the inclusion of a WHILE *statement that allows a list of items to be done as long as a given condition evaluates to a nonzero ("true") value. The other is the ability to redefine the turtle's shape under program control. This can be used to change the turtle's default shape (an odd, elongated capsule shape) or even to perform some limited animation by rapidly redefining the turtle shape.*

Although some bugs will be fixed in the final version, one deserves mention because there may not be enough available memory with which to fix it. It has to do with the method Color Logo uses to draw lines. For example, if you say:

```
HOME
RIGHT 30
FORWARD 20
```

you will get a line that is 30 degrees from the vertical. (Color Logo does not accept multiple commands per line.) If, however, you say

```
HOME
RIGHT 30
REPEAT 20 (FORWARD 1)
```

you will get a line that is 45 degrees from the vertical. The reason for this is that Color Logo, like other Logos, can plot an adjacent dot in only one of eight directions (the eight points of a compass); unlike other Logos, however, Color Logo does not remember where the theoretical point is in relation to the plotted point. The result is that executing FORWARD 1 *twenty times will force the turtle to draw a line on one of the eight points of the compass (depending on the true heading of the turtle and which point it's nearest to). This property of the preliminary version of Color Logo I looked at is unfortunate, since it creates a discrepancy between what you think Logo should do and what it actually does. Still, such a simplification is understandable given the complexity of Logo and the limited memory space of the TRS-80 Color Computer; if this behavior is in the finished product, I'll certainly understand.*

In general, this looks like a nice Logo for children. As always, you should check the product's capabilities against its intended use and audience. Radio Shack plans to have Color Logo in its stores by September 1982.■

Text continued from page 242:

"turnkey" system. If a Logo file named STARTUP is on your data disk when you first boot up Logo, that file is automatically loaded into the Logo workspace. If a Logo variable named STARTUP has a value that is a list, that list is executed after loading the startup file. In this way, a nontechnical user can follow the standard Logo booting procedure and end up with a customized workspace running a certain program.)

Property lists are lists of characteristics that can be associated with a given Logo variable. For example, you may have a number of words that describe geometric shapes: TRIANGLE, SQUARE, PENTAGON. You can then give each of these words two properties, NUM.OF.SIDES and INTERIOR.ANGLE, and assign values to them. Using the name SQUARE as an example, you would first add the properties and their values to the property list associated with SQUARE:

```
PPROP "SQUARE "NUM.OF.SIDES 4
PPROP "SQUARE "INTERIOR.ANGLE
  90
```

You can then print out the property list of SQUARE (the computer's responses are in italics):

```
SHOW PLIST "SQUARE
[INTERIOR.ANGLE 90 NUM.OF.SIDES
  4]
```

At a Glance

Name
Terrapin Logo

Type
Programming language

Manufacturer
Terrapin Inc.
678 Massachusetts Ave., #205
Cambridge, MA 02139
(617) 492-8816

Price
$149.95

Authors
Leigh Klotz Jr., Patrick Sobalvarro, Stephen Hain

Format
5¼-inch floppy disk

Language Used
6502 machine language

Computer Needed
Apple II or Apple II Plus with 48K bytes of memory and 16K memory card

Software Included
One Logo Language Disk (copy protected; backup available for $15), one Utilities Disk (with utilities from MIT and Terrapin)

Documentation
Terrapin Logo Tutorial, 86 pages (draft version); Logo for the Apple II: Technical Manual, by Harold Abelson and Leigh Klotz Jr., 55 pages

Audience
Anyone interested in Logo

or you can get the value of a given property:

```
SHOW GPROP "SQUARE
  "NUM.OF.SIDES
4
```

Note that the word SQUARE can be either a variable with a value or a procedure with a definition; its property list is connected to but not the same as the word itself. Property lists can be useful in certain list-manipulating applications. (By the way, it would not be very hard to make a set of Logo procedures that do the same thing for most of the other Logos; Harold Abelson does this—he calls them *association lists*—in his two books, *Apple Logo* and *Logo for the Apple II*.)

CATCH and THROW are two unlikely Logo commands that allow a given condition to cause the execution of a list of commands. Normally, there's nothing special about that—an IF statement will do the same thing—but in this case, the triggering condition may be a Logo error. If so, a Logo program can intercept the usual Logo response to that error and substitute a user-specified response; this allows a program to recover from specified errors instead of ending.

Apple Logo contains a number of useful commands that are not in the other Logos reviewed here. Although most of them can be defined by the user, it is nice to have them available automatically. Examples of such commands are COUNT (which returns the number of items in a list), ITEM (which returns the *n*th item of a list), and numerous predicate words that return a value of "TRUE or "FALSE depending on the logical value of whatever is being tested (EMPTYP, KEYP, WORDP, and others). Apple Logo also lets you redefine the primitive operations supplied with the language; although most people won't need to do this, it's nice to be able to.

Several other features are worth mentioning. One characteristic of all Logos is that any named variable becomes global to the workspace (and so has the same value within any procedure in it) unless the name is an argument to a procedure (these are called *dummy arguments* in other computer languages). Apple Logo has added a LOCAL statement that restricts the domain of any variable named by it to the procedure that uses the LOCAL statement and any procedures it calls. This often helps prevent hard-to-find program errors resulting from unsuspected interaction between variables.

Users of Apple Logo will probably be able to buy a peripheral board for the Apple that will give it sprites (colored, moving images of varying shapes—see the discussion on sprites in the section on TI Logo, below).

Logo Computer Systems Inc. (which created Apple Logo) showed me a prototype of a sprite board that the company plans to market by the end of 1982. Multiple sprites will be able to move on screen at a time, and they will be able to draw lines, just as a turtle can. (TI Logo sprites do not draw lines.) Once this happens, TI Logo will lose one of its main advantages over the versions of Logo for the Apple II. (At this writing, we have no details on availability or price.)

Apple Logo: Problems

I found one bug in Apple Logo and several things I didn't like. The bug occurred as follows:

```
SHOW SENTENCE -5 3
[-5 3]
SHOW SENTENCE +5 3
[8]
```

Apple Logo should have returned *[5 3]*. The error occurs in the parsing of the phrase +5 3 and has nothing to do with the SENTENCE command itself. Apple Logo shows a certain resemblance to LISP in allowing an operator-number-number construct for the operations of addition, subtraction, multiplication, and division. So Apple Logo behaves as follows:

```
PRINT + 5 3
8
PRINT / 12 4
3
```

It seems that something in the parsing algorithm cannot distinguish between +5 3 and + 5 3. Although this is definitely an error, it probably will not occur in normal programming because people do not usually place plus signs before positive numbers.

A command I don't like is the Apple Logo IF statement. In Terrapin/Krell Logo, an IF statement looks like this:

```
IF :RESO THEN MAKE "RES :RES - 1
  ELSE MAKE "RES :RES + 1
```

In Apple Logo, this becomes:

```
IF :RESO [MAKE "RES :RES - 1] [MAKE
  "RES :RES + 1]
```

At a Glance

Name
TI Logo

Type
Programming language

Manufacturer
Texas Instruments Customer Relations
POB 53
Lubbock, TX 79408
(800) 858-4565

Price
$129.95

Author
Jointly developed by Texas Instruments Corporate Engineering Center and the MIT Logo Group

Format
Command Module (read-only memory cartridge)

Language Used
9900 machine language

Computer Needed
Texas Instruments TI-99/4 or TI-99/4A with 32K-byte memory expansion option and either cassette recorder or floppy disk

Software Included
One Command Module containing TI Logo; a cassette and floppy disk containing TI Logo demonstration programs

Documentation
TI Logo, 83 pages; booklet of documentation for the demonstration programs

Audience
Anyone interested in Logo

In Apple Logo, both the THEN and the ELSE clauses of the IF statements are actually lists. If the expression evaluated is true, the first list is executed; if it is false, the second list is executed. This particular syntax seems arbitrary to me, and it might seem rather cryptic to someone who has not dealt with computers before. In addition, if you write an IF statement without the brackets, you get an error message that is unrelated to the IF statement or the absence of brackets. This makes the debugging process longer. Given the apparent Apple Logo philosophy of tailoring the system to the nontechnical user, I'm surprised the IF statement was implemented this way.

Apple Logo seems to enjoy making inputs to certain commands into lists. For example, the commands SETPOS, TOWARDS, IFTRUE, and IFFALSE require their arguments to be made into lists. Given, say, variables XVAL and YVAL that have numeric values, in Terrapin/Krell Logo, you would say:

```
SETHEADING TOWARDS :XVAL
  :YVAL
```

However, Apple Logo requires you to make a list of the :XVAL :YVAL pair. So the Apple Logo version has to be:

```
SETHEADING TOWARDS LIST :XVAL
  :YVAL
```

The word LIST has to precede the values of XVAL and YVAL because the TOWARDS command requires as input a list with two numbers in it. (You can't simply say [:XVAL :YVAL] because brackets prevent the evaluation of :XVAL and :YVAL.) Like the use of the IF statement, the use of brackets (or any other list-making words) seems to me arbitrary, cryptic, and error inducing.

I am amazed and horrified to find that Apple Logo does not provide for comments in Logo programs.

Finally, there is an omission in the Apple Logo system that I find quite inexcusable—Apple Logo has no provision for putting comments in Logo programs. According to someone at Logo Computer Systems Inc., comments were not allowed because they caused procedures to take up too much space. I find this a rather weak excuse for a language that purports to teach good programming habits and make programming easy for beginners. Making comments in programs, regardless of the language used, is one of the cornerstones of good programming practice, and I am amazed and horrified to find that Apple Logo does not provide for them (all the other Logos except the TRS-80 Logo do).

There is, however, a way around the lack of comments in Apple Logo. Simply define a short procedure that takes a list as an input and does nothing with it:

```
TO ; :ARG
END
```

This defines the Logo procedure ";" which will "eat" any list that comes directly after it. You can now add comments to a program by putting brackets around them and a semicolon and a space just before the opening bracket:

```
TO DUMMY.PROGRAM
; [THIS COMMENT WILL BE
  IGNORED]
END
```

This method, however, may have speed and program-size side effects because the comments are actually a part of the procedure and are executed every time the procedure is executed. As for the necessity of putting brackets around things—you're getting used to that by now, aren't you?

Terrapin/Krell Logo

Both Terrapin Inc. and Krell Software Corporation are licensed to distribute MIT Logo, a version of Logo developed by the Logo Group of the Massachusetts Institute of Technology. (This implementation was created by Leigh Klotz Jr., Patrick Sobalvarro, and Stephen Hain under the direction of Harold Abelson.) Though the language is the same for both companies' versions, the materials supplied with each version differ. The main differences are as follows: Krell Logo includes a second (copy-protected) Logo disk, a set of introductory programs called "Alice in Logoland," a program called INSTANT.LOGO.TUTOR, a nice reference-guide wall poster, and a copy of *Logo for the Apple II*, by Harold Abelson. Terrapin Logo includes only one Logo disk (you can buy an extra one for $15), a copy of *Logo for the Apple II: Technical*

Listing 3: *An example of the* TRACE *function tracing the execution of the Logo phrase* STR.GR.THAN "IT "IS.

```
TRACING ON
EXECUTING STR.GR.THAN IT IS
  IF :FIRST = :SECOND OUTPUT "FALSE
  IF :FIRST = " OUTPUT "FALSE
  IF :SECOND = " OUTPUT "TRUE
  MAKE "CHAR1 FIRST :FIRST
  MAKE "CHAR2 FIRST :SECOND
  IF ASCII :CHAR1 > ASCII :CHAR2 OUTPUT "TRUE
  IF ASCII :CHAR1 < ASCII :CHAR2 OUTPUT "FALSE
  OUTPUT STR.GR.THAN BUTFIRST :FIRST BUTFIRST :SECOND
EXECUTING STR.GR.THAN T S
  IF :FIRST = :SECOND OUTPUT "FALSE
  IF :FIRST = " OUTPUT "FALSE
  IF :SECOND = " OUTPUT "TRUE
  MAKE "CHAR1 FIRST :FIRST
  MAKE "CHAR2 FIRST :SECOND
  IF ASCII :CHAR1 > ASCII :CHAR2 OUTPUT "TRUE
ENDING STR.GR.THAN
ENDING STR.GR.THAN
RESULT: TRUE
```

Manual, and a copy of the *Terrapin Logo Language Tutorial*, by Deborah Tater and Patrick Sobalvarro.

Your choice of the Krell or Terrapin version of MIT Logo will depend on your own preferences. On one hand, Terrapin now employs one of the persons who implemented MIT Logo and consults with another (Leigh Klotz Jr. and Patrick Sobalvarro, respectively). Terrapin will offer revised versions of Terrapin Logo for $20; also, if you find an error in Terrapin Logo during the 90-day warranty period and Terrapin has corrected it, you will receive the revision containing the correction free. The tutorial book by Tater and Sobalvarro is very good. Although it is geared for the novice, it does a very good job of introducing some advanced Logo concepts. Finally, Terrapin may be offering a version of its Logo that implements sprites (more on that below).

I found the programs supplied by Krell competent but simplistic; however, the "Alice" programs might be of interest to children. Krell also offers more support materials, though many of them were not available at press time and so could not be evaluated. Abelson's excellent tutorial book is geared to the beginning, nontechnical user. I prefer the Terrapin version, largely because of its superior technical support and the availability of a sprite version. However, the Krell version offers slightly more materials for the money.

Although both Terrapin/Krell Logo and Apple Logo can be used easily by *any* prospective user, adult and child alike, the differences between them seem to indicate different company perceptions of the intended Logo user. Each version makes a certain class of things easier to do. Although Apple Logo has a richer set of commands, it is delivered to the user as a sealed "black box" that you can't tinker with; in addition, certain features (like the STARTUP file, buried packages, and the necessity of deleting a disk file before it can be resaved under the same name) seem to point toward making the finished application as user-proof as possible. On the other hand, Terrapin/Krell Logo seems to be oriented toward the more knowledgeable user, who doesn't need that extra level of protection. The following paragraphs describe the features of Terrapin/Krell Logo that support this point of view.

The pair of program debugging commands TRACE and NOTRACE is easily the most important feature of Terrapin/Krell Logo. After TRACE has been executed, Logo executes a procedure one line at a time (showing each line as it executes) and waits for

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Filename	Description
ANIMAL	a guessing game about animals that shows Logo's list-manipulating features
INSTANT	a program that lets small children draw pictures using the turtle and one-letter commands
DYNATRACK	a program that introduces a dynaturtle—a turtle that moves according to the laws of Newtonian physics
FID	a file utility program
MUSIC	a set of Logo procedures that plays music through the Apple speaker
SHAPE.EDIT	a program that allows you to change the shape of the Logo graphics turtle
ASSEMBLER	procedures that allow you to define Logo procedures in terms of 6502 assembly-language code
TCL *	a set of Logo procedures that allows a Terrapin turtle robot to be controlled from Terrapin Logo
PSAVE *	a procedure that lets you save only part of the Logo workspace
CURSOR *	added procedures related to the text cursor and text output
TEXTEDIT *	procedures that let you use the Logo editor as a text editor
TEACH *	a procedure that lets you enter procedures without using the Logo editor (for smaller children)
ARCS *	procedures for drawing arcs and circles
INSTANT.LOGO.TUTOR * *	a program that calls up basic information about Logo when the word MENU is executed
KRELLSHAPES.AUX * *	a procedure that allows you to change the turtle to any one of 25 predefined shapes
PSR, PCB, DOT.LINE, SFD, CIRCLE * *	miscellaneous graphics words
LENGTH, XFL, IXL, XNE * *	miscellaneous list-manipulating words

Table 1: *A list of the major files on the Terrapin/Krell Logo Utilities Disk and their function. Files marked with one asterisk are provided with Terrapin Logo only; files marked with two asterisks are provided with Krell Logo only.*

a keypress before executing the next statement. Listing 3 shows an example of executing a Logo statement when the TRACE function is active. In preparing for this review, I wrote several programs and transferred them to all three Logo systems; I can't tell you how much I missed the TRACE function on the three systems that don't have it.

Another convenient feature of Terrapin/Krell Logo is the DOS command, which lets you interact with the Apple DOS (disk operating system). For example, you can rename a file from Logo like this:

```
DOS [RENAME GERBIL.LOGO,
  GERBILWARS.LOGO]
```

The DOS commands this works with are BLOAD, BRUN, BSAVE, CATALOG, DELETE, LOCK, MON, NOMON, RENAME, UNLOCK, and VERIFY.

Terrapin/Krell Logo includes a Logo 6502 assembly-language assembler and sufficient information on the Logo internal structure to make it useful. This is the single feature of Terrapin/Krell Logo that best illustrates its "open-software" as opposed to Apple Logo's "closed-software" philosophy. With the Terrapin/Krell Logo Assembler, you can do a lot of things that can't be done with Apple Logo—anything that requires assembly language or interfacing to the outside world. For example, an assembly-language program to generate a variable-pitched tone through the Apple speaker can be interfaced to Logo and used to create a music-playing program written in Logo.

Sprites are easily the most important feature of TI Logo.

Assembly-language routines can also be used to connect Logo to, say, a nonstandard printer card, a real-time clock, or a tone generator connected through the Apple game paddles. (*Logo for the Apple II: Technical Manual* also includes a two-page list of useful memory addresses and routine entry points as part of an entire chapter on how to write assembly-language routines for Terrapin/Krell Logo and how to use the Logo Assembler.)

The Utilities Disk is another important feature of Terrapin/Krell Logo. It contains the assembler as well as several other useful sets of procedures. Table 1 gives a list of the major files on that floppy disk. Both Terrapin and Krell have put on their Utilities Disks several files that have been created by members of their staffs; each are not, of course, available on the Utilities Disk supplied by the other company.

A special variable called SAVEMOD can be changed to allow using the Terrapin/Krell Logo editor as a text editor. (Without this change, the editor would try to execute the contents of the file.) Some procedures on the Utilities Disk make reading, writing, and printing arbitrary text files easier. The SAVEMOD variable is also useful in making self-starting files (files that, after being loaded into the Logo workspace, automatically execute one or more phrases of Logo).

Terrapin/Krell Logo will work with Steve Ciarcia's sprite board for the Apple (see Ciarcia's column in this issue for details). It is possible that Terrapin will also create a new version of Logo that will integrate sprite and turtle graphics on the same screen and allow sprites to be given movement that is independent of the executing procedure; however, this had not been decided at the time this was written. As with the sprite board for Apple Logo, the availability of one from Terrapin would negate the presence of sprites as one of the primary advantages of TI Logo.

TI Logo: Features

Although people at Texas Instruments worked with people at MIT to create TI Logo, this Logo is not as

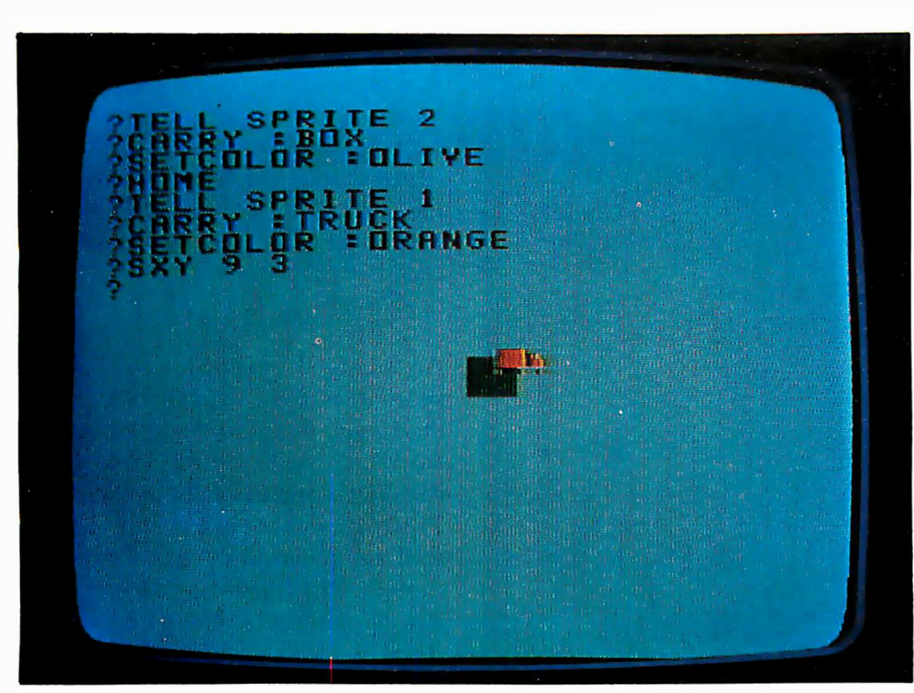


Photo 2: *Priority in TI Logo sprites. The sprite with the lower number (a truck) appears to be on top of the sprite with the higher number (a box).*

similar to the Apple-based Logos as they are to each other. Some of the differences will make TI Logo the best system for some people, but most of them, in my opinion, will severely limit TI Logo's usefulness. I'll consider the features of TI Logo first, then its limitations.

Sprites are easily the most important feature of TI Logo. They are colored video images (up to 16 dots wide by 16 dots high) that are an inherent part of the TI-99/4A. The TI-99/4A has 32 sprites built into it, and each sprite can be given a shape, color, and position on the video display (independent of the text being displayed); in addition, the sprites have an inherent priority of display among themselves, so that when two sprite images intersect, one sprite appears to be on top of the other (see photo 2). This priority is automatically maintained by video circuitry inside the TI-99/4A.

TI Logo adds some features to the hardware-inherent features of sprites. Sprites (like turtles) can be given a heading, but, unlike turtles, they can also be given a velocity. In other words, sprites move in a straight line at a given speed *without slowing down the running program* until they are told to change their behavior; in fact, they also move even when no program is running. The reference list, which includes all the sprite commands, shows TI Logo's superiority over the Apple-based Logos in this respect. However, sprites are unlike turtles in that they cannot draw lines.

Closely related to sprites are sprite shapes. Five are defined by name: PLANE, TRUCK, ROCKET, BALL, and BOX. (Because sprite shapes are called by number, these are actually variables with the values 1 through 5.) Sprites can also be given one of 16 colors, and the attributes of shape, color, heading, and speed can be assigned to a sprite by the following Logo commands.

```
TELL SPRITE 2
(makes sprite 2 "listen" to the
   commands that follow)
CARRY :BALL
(gives it the predefined "ball" shape)
CARRY 4
(does the same as CARRY :BALL)
SETCOLOR :RUST
(gives it an orange-brown color)
SETCOLOR 8
(does the same as SETCOLOR :RUST)
SETHEADING 90
(makes it point to the right)
SETSPEED 48
(starts it moving at a speed of 48)
```

Note that the *number* of the sprite (in this case, *sprite 2*) and the *shape* of

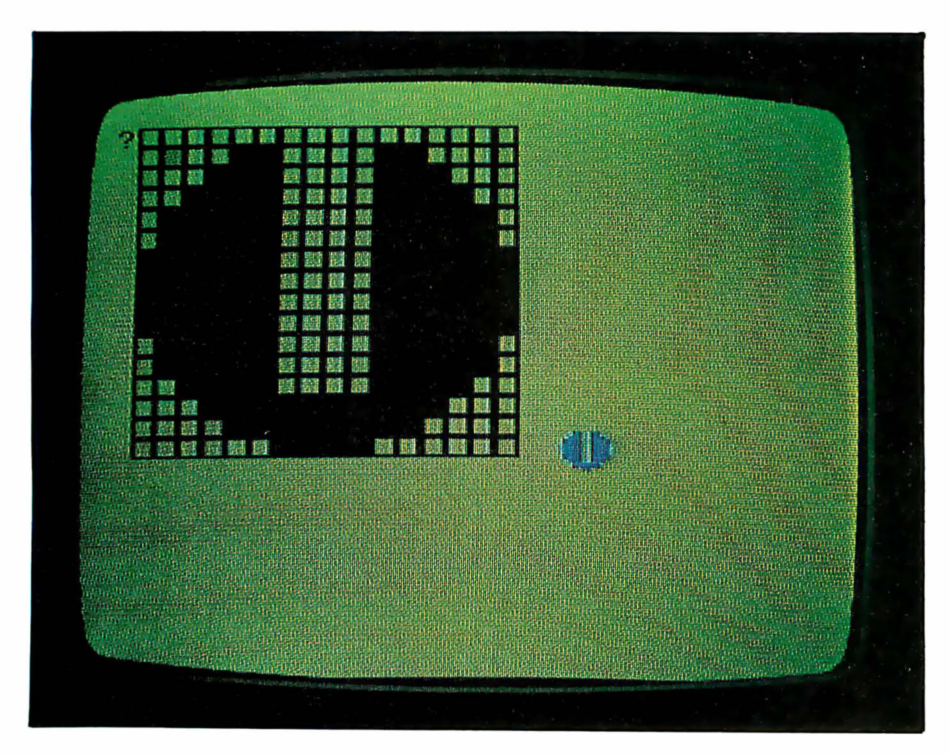


Photo 3: *The* MAKESHAPE *procedure in TI Logo. When* MAKESHAPE n *is executed, sprite shape* n *is displayed in enlarged form and is available for editing. The graphics cursor, a blinking box, can be moved to any box with arrow keys; when the cursor leaves a box, the box can be left either filled in or empty. Any sprites carrying that shape immediately assume that shape, as can be seen by the small sprite of the same shape on screen.*

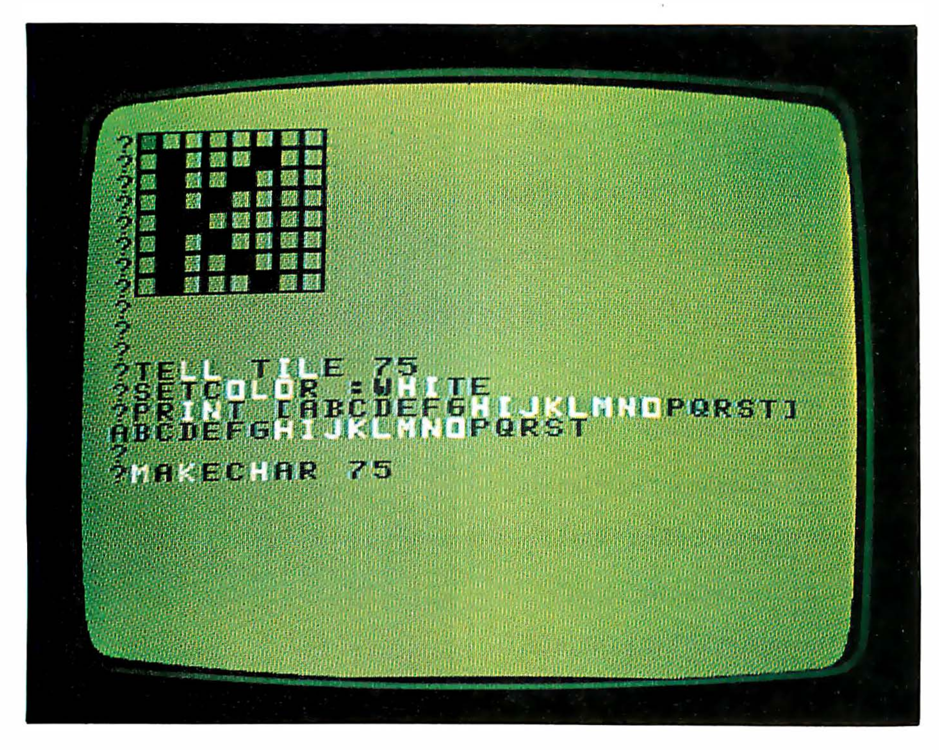


Photo 4: *Tile recoloration and redefinition. As this photo illustrates, both the shape and color of a tile (character) can be changed. Notice that changing the color of a single tile also changes the color of the other seven tiles in the same group.*

the sprite (in this case, *shape 4*) are different.

New sprite shapes (numbered from 0 to 25) can be created (or existing sprite shapes can be redefined) with the MAKESHAPE command. For example, to redefine shape 4, the ball, type:

MAKESHAPE 4

An enlarged version of the ball appears in a 16 by 16 grid with a blinking square denoting the graphics cursor. A square is cleared when an arrow key is pressed and filled when the TI-99/4A function key (or TI-99/4 shift key) is pressed (see photo 3). Although this scheme certainly works, it is hard to go across a complicated shape without accidentally changing it; it would be nice if the graphics cursor had a nondestructive mode that allowed it to move without changing the shape underneath it. When the Back key is pressed, the modified shape (in this example) becomes shape 4. (Unfortunately, there is no way to exit the shape-making process and leave the shape as it was before editing began.)

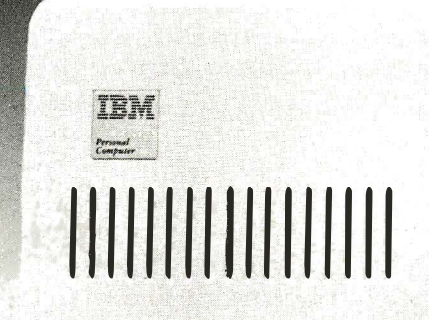
Tiles are TI's nontechnical name for characters, which are patterns in an 8 by 8 grid. (Interestingly enough, certain TI Logo commands like MAKECHAR and PRINTCHAR refer to them as characters, while the documentation and some other commands—TELL TILE *n* and PUTTILE—refer to them as tiles.) There are 256 tiles available in the system, 64 of which are used for the TI Logo character set. Any tile can be redefined with the MAKECHAR command, which works like the MAKESHAPE command described above.

Tiles can also, to a certain extent, be given a different color. Tiles are grouped by ascending tile number in sets of 8, and a tile can be given one of 16 colors by using the SETCOLOR command:

```
TELL TILE 78
SETCOLOR :LEMON
(or SETCOLOR 11)
```

These commands will cause the letter N (which is tile 78) to change to a cer-

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Disk controller card and one floppy disk	645.00
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Terrapin/Krell Logo	149.95
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Disk-based TI Logo system:	
TI-99/4A computer (includes RF modulator)	$450.00
PHP1200 Peripheral Expansion Box	249.95
PHP1260 Memory Expansion Card	299.95
PHP1240 Disk Controller Card	249.95
PHP1250 Expansion Box Disk Drive	399.95
PHM3040 TI Logo cartridge	129.95
	$1779.75
Cassette-based TI Logo system:	
TI-99/4A computer (includes RF modulator)	$450.00
PHP2200 Memory Expansion	399.95
cassette recorder (approximate price)	50.00
PHM3040 TI Logo cartridge	129.95
	$1029.90

Table 2: *Comparative prices of Logo systems. The table shows the list prices of Logo systems based on Apple Logo, Terrapin/Krell Logo, TI Logo with a floppy disk, and TI Logo with a cassette recorder, respectively. These comparisons assume that a color television (not included in the prices) will be used for video display.*

tain shade of yellow. However, all the other tiles in its group (the letters H through O) will also be changed to that color; photo 4 shows an example of this.

Given that the Apple-based Logos will probably have sprites available, the low cost of a TI-based Logo system is one of its biggest advantages. Table 2 shows the comparative costs of four Logo systems: two Apple-based Logos and two TI-based Logos, one supporting a floppy disk, and one supporting a cassette recorder. Schools wanting to buy multiple Logo systems will be particularly interested in the cassette-based TI Logo systems; however, the low cost of a cassette-based system is offset somewhat by the unending difficulties of working with cassette tapes.

The price advantage of a TI Logo system is impressive—about $700 between the Apple-based Logos and a disk-based TI Logo, and over $1500 between the Apple-based Logos and a cassette-based TI Logo. (The price difference may actually be greater—some dealers discount the TI product line significantly, while it is increasingly difficult to buy Apple IIs at a discount.) In fact, even including the color television sets, you can almost buy two cassette-based TI Logo systems for the price of one Apple-based Logo system. Granted, other factors will influence your decision: the computer (if any) you own, the needs and characteristics of the intended users, and the other intended uses (if any) of the computer.

TI Logo: Problems

Unfortunately, there are several things wrong with TI Logo. Most of these problems won't matter for cer-

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edit records ***delete records***
update records ***print out records***

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2. Define data fields, including type and format
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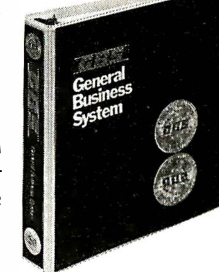
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tain users, but they will be very important to others. You should ask yourself how important these problems are to you.

One problem I want to mention, keyboard layout, should be attributed to the TI-99/4A computer rather than TI Logo itself; and two others, turtle drawing behavior and slowness of execution, are probably attributable to the computer as well. The poor layout of the TI-99/4 and TI-99/4A keyboards is well known and does not need to be amplified here. The latter keyboard is improved in that it has true typewriter keys instead of button-type keys, but one knowledgeable TI Logo observer says that the TI-99/4A keyboard is more difficult to use for Logo than the TI-99/4's.

In any case, the TI-99/4A keyboard still infuriates anyone with any keyboard skills. (This would be less of a problem for children who do not know how to type, but it would put them at a disadvantage when using other keyboards.) Two often-used keys, the backspace and double-quotes (") keys, use a poorly placed FCTN key. The FCTN key is below the right shift key; backspace is FCTN-3 and the double-quotes key is FCTN-P. In addition, some FCTN keys that are active within the TI Logo editor are inactive outside it, while others are active in both places. This leads you to try certain FCTN keys to see if they accomplish a given editing task; not only do they not, but they aren't truly inactive, either—they leave funny-shaped graphics characters (FCTN-4, when used outside the editor, is an example of this).

I also blame the slowness of TI Logo (see the section on benchmarks later) on the computer itself, although I am not completely sure of this. All I know is that TI BASIC is also very slow (even though the TI-99/4A uses a 16-bit 9900 processor) and that the machine has a reputation for being slow.

The fact that the TI Logo turtle "runs out of ink" rather quickly is due to the decision to implement the lines the turtle draws with tiles (see the section labeled "Common Features," page 230). I do not know of any dot-graphics mode available on the TI-99/4A, which leads me to believe that this was the only way to create turtle graphics; the limitation is the fault of the machine itself and not the implementation of TI Logo.

Two other problems with TI Logo concern the language itself. One, some moderately serious problems with the TI Logo printed documentation, will be covered more fully in a later section. The other, integer-only arithmetic, has been mentioned in the "Common Features" section. Being limited to integer arithmetic would not be a disadvantage for simple Logo applications (the beginning Logo programs of children, for instance). Floating-point numbers are often useful, if not necessary, for many fairly simple applications; for example, the Apple-based Logos can draw arcs and circles with greater control because of the availability of floating-point numbers.

TI Logo: Undocumented Features

Through experimentation and conversations with various people in the TI Logo community, I found several Logo commands that are in TI Logo but are not documented. The fundamental list-manipulating commands FPUT and LPUT work, as do several predicate words—NUMBER?, THING?, and WORD? (for definitions, see the words NUMBERP, THINGP, and WORDP in the reference list).

Another command that I was told about and later confirmed, DEBUG, toggles an internal trace mode between on and off states. When the trace mode is on and a procedure is executed, any error condition causes the procedure to pause (rather than simply end) with a prompt telling you what level you are at. You can then execute statements from the keyboard to determine (and perhaps correct) what is wrong, then type CONTINUE to continue execution.

TI Logo: Implementation Errors and Poor Design Decisions

In this section, I am going to cover some of the more serious errors in TI

Listing 4: *Two memory-filling procedures.* FILLMEMORY *fills memory by creating an infinitely nesting procedure that prints out its current depth.* FILLPROC *creates short empty procedures of equal length under program control. Listing 4a shows the version used by Terrapin/Krell Logo, while listing 4b shows the version used by TI Logo. The procedure* MAKEQQ *must be executed once before the TI Logo memory-filling procedures will work.*

(4a)

```
TO FILLMEMORY :N
  PRINT1 [AT LEVEL] PRINT :N
  FILLMEMORY :N + 1
  PRINT1 [SECOND TIME AT LEVEL] PRINT :N
END

TO FILLPROC :N
  PRINT1 [AT LEVEL] PRINT :N
  MAKE "PROCNAME WORD "P :N
  DEFINE :PROCNAME [[]]
  FILLPROC :N + 1
END
```

(4b)

```
TO MAKEQQ
  MAKE "QQ "1234567890ABCDEFGHIJKLMNOPQRSTUVWXYZ
END

TO FILLMEMORY :N
  TYPE [AT LEVEL] PRINT :N
  FILLMEMORY :N + 1
  TYPE [SECOND TIME AT LEVEL] PRINT :N
END

TO PICK :N :WORD
  IF :N = 1 THEN OUTPUT FIRST :WORD
  OUTPUT PICK :N - 1 BUTFIRST :WORD
END

TO FILLPROC :N
  TYPE [AT LEVEL] PRINT :N
  MAKE "PROCNAME WORD "P PICK :N :QQ
  DEFINE :PROCNAME [[]]
  FILLPROC :N + 1
END
```

Logo itself. Some of these can be called *poor design decisions*—in other words, the people who designed TI Logo decided to implement a feature in a way that resulted in an awkward situation that could have been averted. At least one of these is an *implementation error*—a "bug" in the program that shouldn't be there. Several errors that I discuss below could be called either poor design decisions or implementation errors, depending on your point of view.

The word/number dichotomy: TI Logo regards words and numbers as noninterchangeable items (in the Apple-based Logos, numbers *are* words). This changes the behavior of several Logo words. For example, the Apple-based Logo will behave as follows:

```
MAKE "NUM1 14
(make NUM1 equal to 14)
MAKE "VAR1 WORD "XXX :NUM 1
(make VAR1 equal to the string XXX
   followed by the value of NUM1)
PRINT :VAR1
(print the value of VAR1)
XXX14
```

However, TI Logo will not do this. Instead, it returns the message:

```
WORD DOESN'T LIKE 14 AS INPUT
```

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Several TI Logo commands—WORD, FIRST, BUTFIRST, LAST, and BUTLAST—behave as shown above. This causes a lot of problems when you are trying to create words during program execution. In the benchmark program FILLPROC, I wanted to create a series of procedures, P1, P2, P3, and so on. I did this easily in the Apple-based Logos (see listing 4a), but I had to create the procedure names differently in the TI Logo version (listing 4b).

A "hole" in the instruction set: The TI Logo version of the FILLPROC procedure is also different from the Apple-based Logo versions in that TI Logo has a "hole" in its instruction set. Like the Apple versions, TI Logo has a command to convert a character to its numeric equivalent (CHARNUM in TI Logo), but (unlike the Apple versions' CHAR) there is no command to convert a number to its character equivalent. If there had been, I could have replaced the phrase

```
WORD "P PICK :N :QQ
```

in the TI Logo version with the phrase

```
WORD "P CHAR :N
```

and **deleted the procedure PICK and the variable QQ.**

An unexplained irregularity in the evaluation of Logo phrases: Another design decision is an odd algorithm for evaluating Logo phrases. This results in a bug I found when transferring the STR.GR.THAN procedure (see listing 2) from Terrapin/Krell Logo to TI Logo. Using a slightly different example, the Apple-based Logos had no problem with the phrase

```
PRINT ASCII "B > ASCII "A
TRUE
```

The TI Logo version (which uses CHARNUM in place of ASCII) acts as follows:

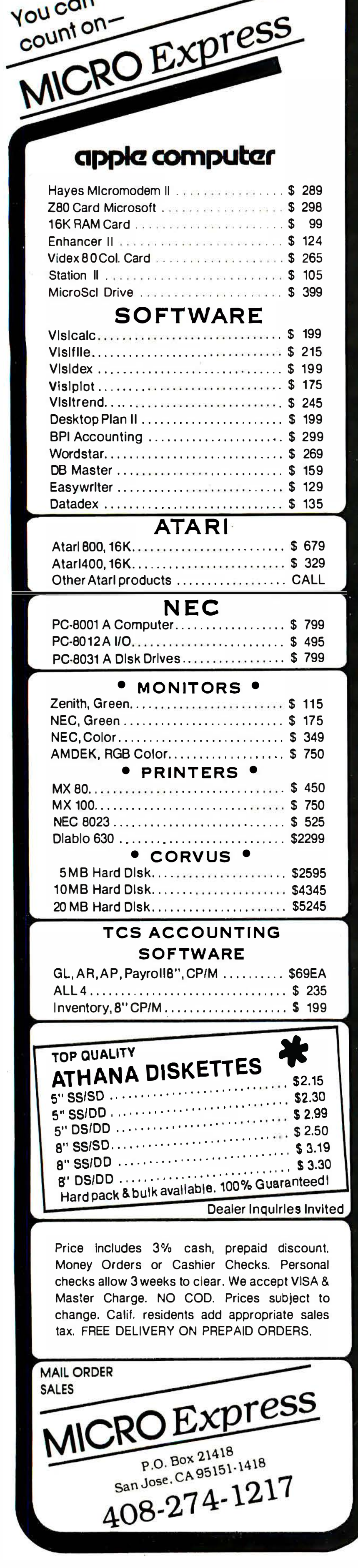
```
PRINT CHARNUM "B > CHARNUM "A
>DOESN'T LIKE B AS INPUT
```

After some experimentation, I found that TI Logo returns the correct value **of TRUE given the command**

```
PRINT (CHARNUM "B ) >
  CHARNUM "A
```

It seems that TI Logo scans an expression from right to left (which is okay in itself) and evaluates CHARNUM "A to a value of 66. It then tries to make the comparison "B > 66 and returns the above error message. The parentheses in the corrected version force the evaluation of CHARNUM "B before the greater-than comparison is made. I am at a loss to explain why this happens. At first, I thought TI Logo evaluates expressions strictly right to left without any idea of operator precedence, but several experiments with the arithmetic operators FIRST, BUTFIRST, and WORD showed that TI Logo *does* evaluate certain operations before others.

Now we get to a realm in which the problems can be blamed on either poor design decisions or implementation errors. I think they are outright errors because they are different from the internal models I (and most people) have of Logo. Another reason for calling them errors is that they are not pointed out in the documentation.



You find out about them when programs don't work, and it takes a long time to find the error because your internal model of Logo behavior suggests you look elsewhere for the error.

The absence of an empty string: I found this decision/error while debugging the TI Logo version of the procedure STR.GR.THAN, which determines whether one string is alphabetically greater than another (see listing 2). The procedure is recursive, and one ending condition is the empty string—a string (word) with zero characters in it. In other words, the Apple-based Logos work like this:

```
MAKE "STRING "AD
(makes the variable STRING equal to
  AD)
PRINT :STRING
AD
(print the value of STRING)
MAKE "STRING BUTFIRST :STRING
(make the variable STRING equal to all
  the characters but the first of the
  value of STRING)
PRINT :STRING
D
(STRING is now one character long)
MAKE "STRING BUTFIRST :STRING
  PRINT :STRING

(nothing is printed because STRING is
  zero characters long)
PRINT :STRING = "
(is the value of STRING the empty
  string?)
TRUE
(yes, it is)
```

TI Logo works the same as above, with the following exception:

```
PRINT :STRING
(we're starting in the middle here)
D
(the current value of STRING)
MAKE "STRING BUTFIRST :STRING
  PRINT :STRING
D
(what's wrong here?)
PRINT :STRING = "D
TRUE
PRINT (BUTFIRST "D ) = "D
TRUE
(BUTFIRST of a single-letter word is the
  word itself!)
```

TI Logo string-manipulating procedures have to be written with the knowledge in mind that BUTFIRST of a single-character word is the word itself. Unfortunately, the documentation doesn't tell you anything about this. Is this an implementation error or a poor design decision? You tell me.

The odd behavior of numbers enclosed by brackets: Another decision/error is that TI Logo, unlike the Apple-based Logos, incorrectly parses lists that include negative numbers. Apple Logo does the following:

```
PRINT FIRST [ -2 4 -3]
-2
PRINT LAST [ -2 4 -3]
-3
```

TI Logo does the following:

```
PRINT FIRST [ -2 4 -3]
-
PRINT LAST [ -2 4 -3]
3
```

Again, you have to know about this kind of behavior before you program in TI Logo, and it's not documented in the reference material. What's more, this situation makes programming in TI Logo more difficult. To create a list with negative numbers in it, you have to use the commands SENTENCE, FPUT, and LPUT and place the negative numbers inside parentheses:

```
MAKE "NUMLIST (SENTENCE
  (-2) 4 (-3))
PRINT :NUMLIST
-2 4 -3
PRINT FIRST :NUMLIST
-2
```

Problems with the TI Logo editor: One of the things I don't like about the TI Logo editor (the same applies to the sprite- and tile-making procedures) is that there is no way to exit the editor while leaving the procedure as it was *before* editing started. The Apple-based Logos have this ability (Control-C to exit with the changed procedure, Control-G to exit with the unchanged procedure), but TI Logo has one key only—the Back key. The contents of the editor at that time, like it or not, become the definition of that procedure.

Two other undocumented problems in the TI Logo editor may cause you to make errors. First, if you hit the Back key and the procedure being

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edited doesn't end with an END statement, TI Logo returns to the main Logo screen with a different prompt, a ">" instead of a "?", and you are still defining the procedure. Whatever you type at the keyboard (until you type an END statement) will be added to the definition of the procedure you thought you had finished. Of course, this causes some interesting errors when you try to execute the procedure. (In TI's defense, I must point out that each new procedure is automatically given an END statement when it is first edited; however, it is possible to erase the END statement during editing.)

The second problem occurs if you type in the dummy arguments when you begin editing a new procedure. For example, if you type in

```
TO ADDTWO :NUM1 :NUM2
```

from the main Logo screen, you are placed in the editor with the following information already there:

```
TO ADDTWO
END
```

The TI Logo editor ignores the two dummy arguments, :NUM1 and :NUM2. If you define ADDTWO not realizing that it has no arguments, you will certainly get a confusing error message when you try to execute it.

A TI Logo system error: The last thing I have to report is definitely an implementation error; it occurs when you run the procedure FILLPROC (see listing 4b). The Apple-based Logos stop and report an error message when the memory space is full. TI Logo behavior is erratic. Sometimes it sends the extremely appropriate message CHOKED! and the TI Logo crashes—it does not respond to keyboard input, and the computer has to be turned off and on again. Other times it crashes without the CHOKED! message or (correctly) returns with the message OUT OF SPACE AT LEVEL 57, LINE 2 OF PICK. (I have been told that the CHOKED! message occurs only when the workspace is full and TI Logo can't find enough free memory to print the error message.)

Again, I want to say that these

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poor design decisions and implementation errors may or may not be important to your application; for example, many simple applications will not do any string or list manipulation. Also, the price differential between a TI Logo and an Apple-based Logo system may make you willing to work around the idiosyncrasies of the TI Logo system.

TI Logo: Perspective

Before I finished this article, I talked with Mr. Donald P. Bynum, Division Manager of the Personal Computer Division of Texas Instruments. He was very receptive to the criticisms I made, and he told me how TI is improving its Logo. He was aware of the documentation problem and said that TI was in the process of writing a more complete tutorial book about TI Logo that would be supplied with later versions of the product. In addition, TI is publishing a book/software combination called the *TI Logo Curriculum Guide*, which should be available separately by the time you read this. The price of this product is steep ($49.95), but it contains extensive teacher-oriented material on using Logo at various grade levels as well as a disk and two cassettes of Logo programs for preschool children. The book also contains an 84-page appendix called the *TI Logo Reference Guide*, which fully explains each TI Logo command and gives an example of its use. This reference guide may later be available separately.

Mr. Bynum also told me about about a second version of TI Logo that will be available before the end of the year. This version will include such enhancements as music capability, double-size sprites, a workspace almost twice as large as that of the first version, more extensive documentation, and the ability to print procedures via the RS-232C port. In addition, the new version will no longer "hang up" when it runs out of workspace, and BUTFIRST of a single-letter word will be an empty word. (All other criticisms given here will still be valid.) These improvements will correct many of the current faults of TI Logo.

Listing 5: *Examples of error messages in three versions of Logo. Listings 5a, 5b, and 5c show the error messages for identical errors made in Apple Logo, Terrapin/Krell Logo, and TI Logo during execution of the* FILLMEMORY *procedure (see listings 4a and 4b).*

(5a)

```
Apple Logo:

OUT OF SPACE IN FILLMEMORY
  FILLMEMORY :N + 1
```

(5b)

```
Terrapin/Krell Logo:

NO STORAGE LEFTI, IN LINE
  PRINT1 [AT LEVEL ] PRINT :N
AT LEVEL 114 OF FILLMEMORY
```

(5c)

```
TI Logo

OUT OF SPACE
AT LEVEL 46 LINE 1 OF FILLMEMORY
```

Error Handling

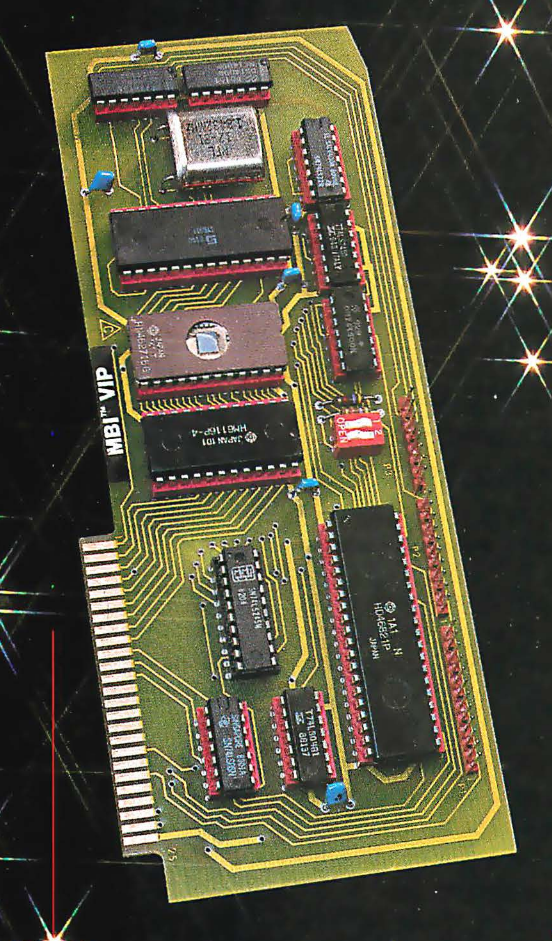
One of the most impressive things about all five Logos is the clarity of their error messages. Unlike the usual vague or cryptic error messages (like SYNTAX ERROR or OM ERROR or ERROR 24), the Logos give you messages like *TELL ME HOW TO xxxx* (when you try to execute an undefined procedure), *YOU TRIED TO DIVIDE BY ZERO*, *FILE IS THE WRONG TYPE*, and *xxxx DOESN'T LIKE yyyy AS INPUT*. Such error messages are made easier by the interpreted nature of Logo (compiled languages usually give less specific error messages). People used to working with computers can get by with poorer error messages, but good error messages are especially important in systems that will be used by beginners and nontechnical people.

However, the Logo systems give different levels of information with the error messages. I created the same error situations in the Apple- and TI-based Logos and recorded the error messages given; see listing 5. Terrapin/Krell Logo gives more detailed error messages than Apple Logo (again, a reflection of the intended user). TI Logo error messages are

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complete but not as easy to use because they give the number of the line in error instead of displaying the line itself.

Documentation

Taking the Logos in alphabetical order again, we start with Apple Logo. The documentation for Apple Logo is in two volumes, both in the half-page spiral-bound format of all the Apple Computer Inc. documentation. (Instead of the metal spiral binding used in all Apple documentation to date, the spiral binding here is plastic; perhaps this is just new packaging, but it might be in deference to young children using the documentation—a nice change, in any case.) The first book, *Apple Logo: Introduction to Programming through Turtle Graphics*, by Cynthia J. Solomon, is the kind of step-by-step, gentle introduction to Logo needed by anyone using a computer for the first time. The book, which is 153 pages long, uses turtle-related projects to cover procedures, file storage and retrieval, the Logo editor, variables, recursion, and most of the graphics-related commands. The subjects covered are explained in an easily understandable way. The book is laid out in a pleasing format that includes many screen shots (to illustrate the turtle's behavior in the examples given); most pages have a wide left margin that gives you a place to write notes (if you're the kind of person who writes in books).

Apple Logo: Reference Manual, by Laurence J. Davidson, is the one book I read cover to cover. It's 186 pages long and covers all aspects of the Apple Logo package. I found it to be comprehensive, well organized, and easy to read.

Terrapin Logo is documented by two books, *The Terrapin Logo Language Tutorial*, by Deborah Tater and Patrick Sobalvarro, and *Logo for the Apple II: Technical Manual*, by Harold Abelson and Leigh Klotz Jr. These two books roughly correspond to the Apple Logo counterparts; the former is the tutorial book, and the latter is the reference manual. In comparison to the Apple Logo manuals, what the Terrapin manuals lack in "polish," they make up for in content. The writing style of the tutorial book is not as calculatedly simple as its Apple Logo counterpart, but it is written in a friendly, conversational way. I think that, again, this is because Apple Logo is intended for a less technical (perhaps younger) audience. In contrast to the Apple Logo tutorial book, *The Terrapin Logo Language Tutorial* covers a larger subset of the Logo world: it includes sections on words, lists, and debugging. Appendix III, which explains rather well the concept of *tail recursion*, is particularly well done. (Tail recursion usually occurs when the last thing a recursive procedure does is call itself. When this occurs, Logo can treat the procedure as iterative instead of recursive, thus saving a lot of memory and allowing Logo to function more efficiently.)

At first, the idea of doing Logo benchmarks seemed almost sacrilegious, like trying to benchmark sunsets. Still, old habits die hard. . . .

Logo for the Apple II, by Harold Abelson (published by BYTE Books), is supplied with Krell Logo in place of the Terrapin tutorial book. It is easily the best tutorial book (for people who don't need the gentle approach of the Apple Logo tutorial book) of the three Apple-based tutorial books. It comes the closest of the three to covering the *entire* Logo instruction set in a tutorial manner. It also has plenty of drawings and charts as well as spiral binding and wide margins on each page.

Logo for the Apple II: Technical Manual is the reference work for both Terrapin and Krell Logos. Its description of individual Logo commands is very terse (as opposed to the Apple Logo documentation, which gives a longer definition and several examples for each word), which may be a problem for some users. However, the manual does devote an entire chapter to the assembler and its use with Terrapin/Krell Logo; this chapter includes a lot of information on the internal structure of Terrapin/Krell Logo, something that Apple Logo does not do.

An 83-page book called the *TI Logo User's Manual* (by Diane R. Musha and other members of the TI Learning Center) is the only documentation available for TI Logo. The first 64 pages are tutorial and cover the TI Logo editor, saving and loading files to cassette or floppy disk, procedures, variables, the turtle, and the special features of TI Logo—sprites and tiles. A 9-page appendix lists and briefly defines all the predefined words in TI Logo; however, I found the definitions of HOME and SETSPEED to be incorrect and also found several basic Logo words (see page 262) that work in TI Logo but that are missing from the appendix. I think it is safe to say that any user will have to buy a supplementary textbook on Logo to get full use of TI Logo; the TI Logo documentation just doesn't tell you all you need to know about the language.

A Few Benchmarks

I don't want to give the impression that I have conducted an exhaustive set of benchmarks for the five Logos—I haven't. At first, the idea of doing Logo benchmarks seemed almost sacrilegious, like trying to benchmark sunsets. Still, old habits die hard, and I *did* try to measure two things—the size of a Logo workspace and the speed of execution of a sample Logo program.

Since the Apple-based Logos measure workspace size in *nodes*, the size of their workspaces can be easily compared. A node is a unit of memory within Logo and is implemented in the Apple versions as 5 bytes. The versions I worked with gave Apple Logo (version 1.5) as having 2818 nodes and Terrapin/Krell Logo (version 1.0) as having 2288 nodes; both measurements were taken with an empty workspace. Although the Apple Logo figure will probably remain the same, Terrapin will be selling revised versions of Terrapin Logo that may have more node space. Still,

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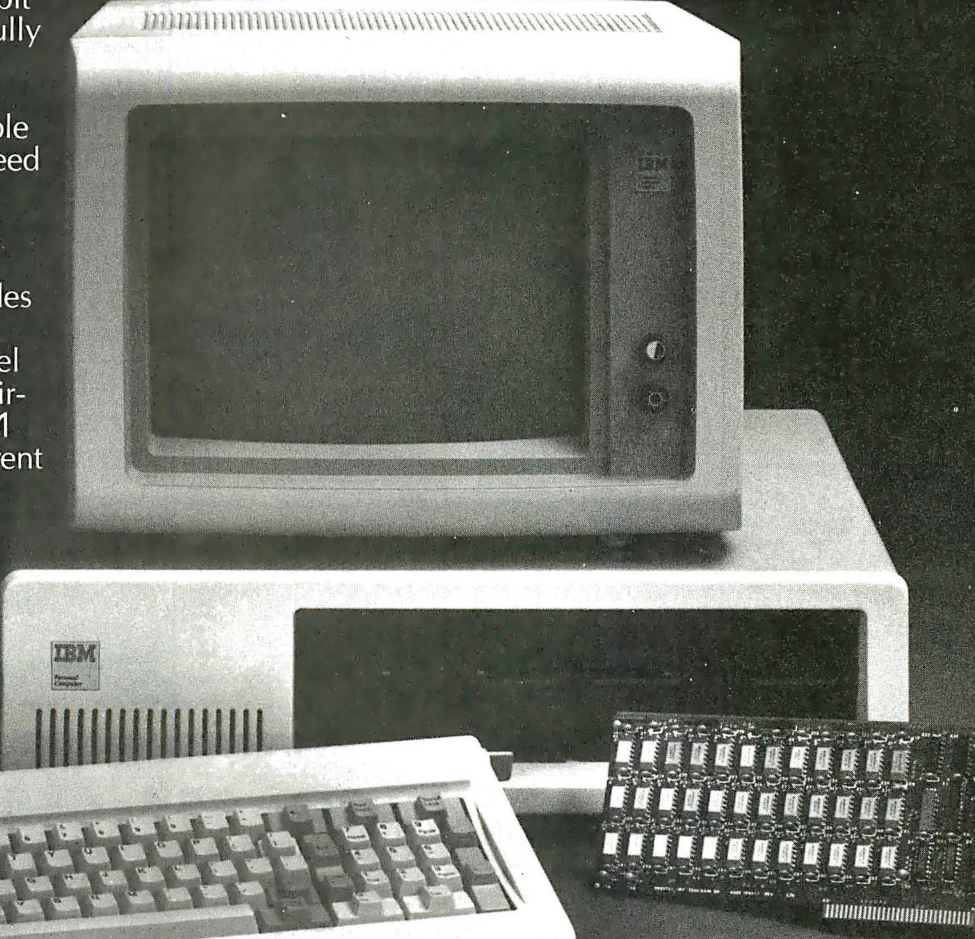
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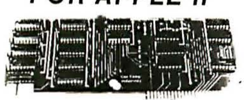
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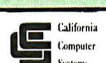


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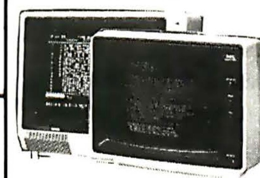
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Procedure Executed	Level Reached by the Computer Running: Apple Logo	Terrapin/Krell Logo	TI Logo
FILLMEMORY	228	114	46
FILLPROC	236	271	29

Table 3: *Workspace size of the three implementations of Logo as indicated by the* FILLMEMORY *and* FILLPROC *procedures. See the section on benchmarks for details (see listings 4a and 4b on page 264).*

the Apple-based Logos are within 20 percent of each other in workspace size.

It is more difficult to compare the Apple-based Logos to TI Logo because the latter does not have a command that returns the workspace size. So I created and ran two procedures that filled memory, thinking that the numbers they returned would be proportional to the relative sizes of the workspaces. (I chose to do a second procedure to confirm the results of the first; with only one procedure, I would have no way of telling whether the assumption that the numbers are proportional to the workspace sizes is valid.) The first procedure, FILLMEMORY (see listing 4a and 4b), fills memory by running an infinitely deep recursive procedure and printing out its current recursion level; the level at which the procedure runs out of memory should be proportional to the workspace size. (The second PRINT statement in FILLMEMORY is used to keep tail recursion, which would prevent true recursion, from happening.)

The second procedure, FILLPROC (see listings 4a and 4b), fills memory by creating a series of empty procedures, P1, P2, P3, and so on; the Logo word DEFINE is used to create new procedures under program control. As described in the last section on TI Logo, the version of FILLPROC had to be implemented differently because of the TI Logo instruction set.

The results of these two tests are given in table 3. The performance of all the Logos on FILLPROC is rather puzzling. Terrapin/Krell Logo (in comparison to Apple Logo) seems to do worse on FILLMEMORY and better on FILLPROC. These numbers should be discarded in favor of the node figures discussed above. In both cases, though, TI Logo did much more poorly than the Apple-based Logos, although I would hesitate to give a percentage figure based on these figures. TI Logo requires 48K bytes of memory (16K bytes in the TI-99/4A itself and 32K bytes in an expansion box), and according to a source at TI, the TI Logo cartridge takes up only a small area of memory itself. Thus the amount of free memory available to TI Logo is roughly equal to that of the Apple-based Logos; I don't think we can attribute the reduced TI Logo capacity to the available memory in the machine.

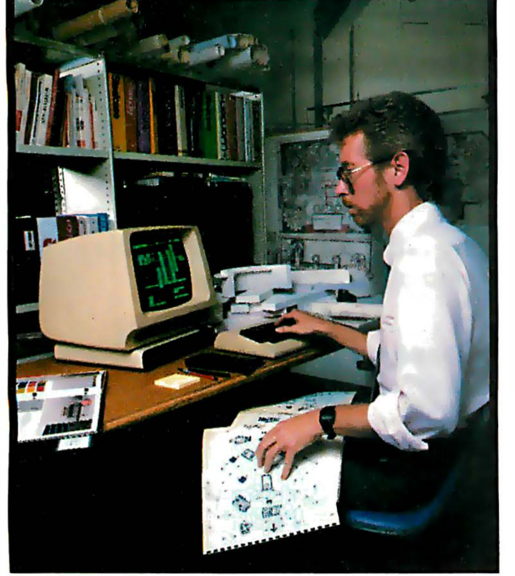
The other set of benchmarks tests the Logos' overall speed performance running a program that relies heavily on recursion (which most Logo programs do) and list manipulation. I used the SORT procedure of listing 2 to sort two lists: first, the list [LOGO IS AN INTERESTING LANGUAGE FOR PICTURE DRAWING, LIST MANIPULATION, AND EDUCATION]; and second, [Z Y X W V U T S R Q P O N M L K J I H G F E D C B A]. The timing results of these benchmark programs, given in table 4, show that Apple Logo is about 10 percent faster than Terrapin/Krell Logo, which will not be noticeable in most situations. TI Logo, however, is slower than the Apple-based Logos by a factor of two.

Which Logo Is Right for You?

If you skipped the rest of this article to read this section, you're out of luck—the answer to the above question is more in the body of this article

Text continued on page 288

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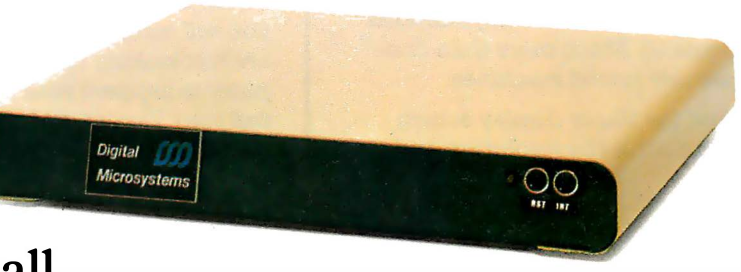


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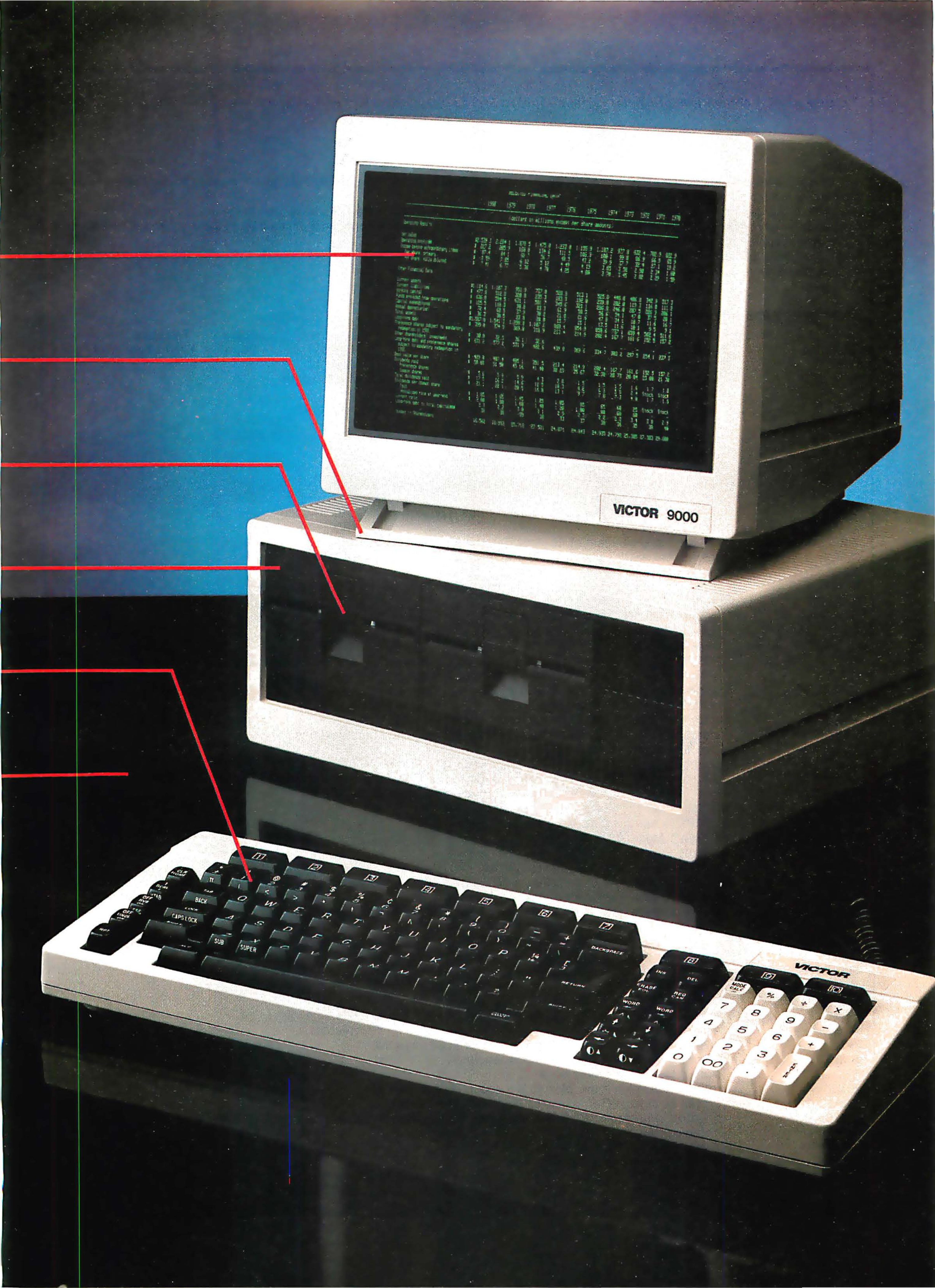
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Reference list: *A comparison of Apple, Terrapin/Krell, and TI Logo nongraphics and graphics-related commands.*

Notes

1. This list does not include the 16 color names (RED, BLUE, ORANGE, and so on) used by TI Logo, nor does it include the two-letter abbreviations available for some Logo commands.
2. Words that perform the same function but have different names are listed alphabetically by first name.
3. An asterisk beside a command denotes that, in Apple Logo, the action of the word can be limited by inclusion of an optional package name; in this case, only objects "contained" in that package are affected.
4. These descriptions are not intended to be complete definitions of individual commands. A thorough understanding of Logo is necessary to understand some of them.

Nongraphics Commands

Command	Description	Apple Logo	Terrapin/ Krell Logo	TI Logo
+, −, */	adds, subtracts, multiplies, divides two numbers (integers only in TI Logo)	x	x	x
=	returns true value if two objects are equal to each other	x	x	x
<, >	does less-than or greater-than comparison on two numbers (integers only in TI Logo)	x	x	x
:	used to get the value of a variable name	x	x	x
;	used to mark the rest of the line as comments		x	x
"	used to prevent evaluation of the word that follows	x	x	x
ALLOF	returns a value of true if all inputs are true (Apple Logo uses AND; TI Logo uses BOTH)	x	x	x
ANYOF	returns true value if any of its inputs is true (Apple Logo uses OR; TI Logo uses EITHER)	x	x	x
ARCTAN	returns the arctangent of its input (Terrapin/Krell uses ATAN)	x	x	
ASCII	returns the ASCII value of the character input (TI Logo uses CHARNUM)	x	x	x
BEEP	starts a tone			x
BURY	isolates a group of procedures from the rest of the Logo workspace	x		
BUTFIRST	returns all but first letter/item of a word/list	x	x	x
BUTLAST	returns all but last letter/item of a word/list	x	x	x
BUTTONP	returns true value if specified paddle button is depressed (Terrapin/Krell Logo uses PADDLEBUTTON)	x	x	
BYE	leaves Logo			x
CALL	assigns a value to a name (Apple Logo uses NAME)	x		x
CATALOG	displays names of all files on current disk	x	x	
CATCH	user-defined error-trapping word	x		
CHAR	returns character with a given numeric value	x	x	
CLEARTEXT	clears all text from screen and puts cursor at beginning of first text line	x	x	
CLEARINPUT	clears character buffer		x	
CO	resumes execution of a procedure after a pause (Terrapin/Krell Logo can also use CONTINUE; TI Logo uses CONTINUE only)	x	x	x
CONTENTS	prints all the active names in the workspace (Apple and Terrapin/Krell Logo use .CONTENTS)	x	x	x
CONTINUE	continues a procedure that has been paused			x
COPYDEF	copies a procedure definition into a new name	x		
COS	returns the cosine of a given input (in degrees)	x	x	
COUNT	returns the number of elements in a list	x		
DEBUG	toggles debug state of computer; when on, the computer does an automatic pause when an error condition occurs			x
DEFINE	allows a new procedure to be defined under program control (without entering Edit mode)	x	x	x
DEFINEDP	returns true value if its input is the name of a defined procedure	x		
DISK	returns drive, slot, and volume number of current disk	x		
DIFFERENCE	returns the difference of two numbers			x
DOS	allows Logo to execute an Apple DOS command		x	
EDIT	allows editing of an existing procedure	x	x	x
EDNS *	allows editing of a group of variable definitions (stands for "edit names")	x		
ELSE	marks action taken if the conditional expression of an IF statement is false (Apple Logo uses brackets in place of ELSE keyword)	x	x	x
EMPTYP	returns true value if object named is an empty list or word	x		
END	signals the end of a procedure	x	x	x
EQUALP	returns true value if two objects are equal (TI Logo uses IS)	x		
ERALL *	erases all objects (Terrapin/Krell Logo uses ERASE ALL)	x	x	
ERASE	deletes the named procedure from the workspace (Apple Logo can delete multiple procedures)	x	x	x
ERASEFILE	erases a file from the disk	x	x	
ERASEPICT	erases a graphics image from the disk		x	
ERN	erases a list of variables from the workspace (Terrapin/Krell Logo uses ERNAME, which erases only one variable; ERN stands for "erase name")	x	x	

Nongraphics Commands

Command	Description	Apple Logo	Terrapin/ Krell Logo	TI Logo
ERNS *	erases a list of variables from the workspace (stands for "erase names")	x		
ERPS *	erases a list of procedures from the workspace (stands for "erase procedures")	x		
ERROR	prints out information explaining the most recent error	x		
FIRST	returns the first letter/item of a word/list	x	x	x
FPUT	makes an object the new first element of an existing list	x	x	x
GOODBYE	reinitializes Logo; all previous work is lost		x	
GO	goto statement for use within a Logo procedure	x	x	x
GPROP	returns the value of a certain property of a variable	x		
GREATER	returns true value if the first of the two numbers is greater than the other			x
IF	signals the beginning of an *if...then...else* construct in Logo	x	x	x
IFF	states the action to be taken if a previous test is false (Apple and Terrapin/Krell Logo also use IFFALSE)	x	x	x
IFT	states the action to be taken if a previous test is true (Apple and Terrapin/Krell Logo also use IFTRUE)	x	x	x
INT	returns the integer portion of a number (Terrapin/Krell Logo uses INTEGER)	x	x	
IS	returns true value if two items are equal			x
ITEM	returns the *n*th item in a list	x		
KEYP	returns true value if a key has been pressed but not yet read (Terrapin/Krell and TI Logos use RC?)	x	x	x
LABEL	within a procedure, used to mark the destination of a goto statement (TI and Terrapin/Krell Logo use the label name and a colon only)	x	x	x
LAST	returns the last letter/item of a word/list	x	x	x
LESS	returns true value if the first of two numbers is less than the second			x
LIST	makes a list from a series of items	x	x	
LISTP	returns true value if the variable named is a defined list (Terrapin/Krell Logo uses LIST?)	x	x	
LOAD	loads the contents of a disk file into the Logo workspace (TI Logo uses RECALL, Terrapin/Krell Logo uses READ)	x	x	x
LOCAL	declares a variable as local to the enclosing procedure without making it the argument of the procedure	x		
LPUT	makes an object the new last element of an existing list	x	x	x
MAKE	assigns a name to a value	x	x	x
MEMBERP	returns true value if the given object is an element of the given list	x		
NAMEP	returns true value if the given name has a value	x		
NOBEEP	turns off the tone started by BEEP			x
NODES	returns the number of free nodes in the system (Terrapin/Krell Logo uses .NODES)	x	x	
NOT	inverts a logical value	x	x	x
NOTRACE	turns off tracing feature		x	
NUMBERP	returns true value if its input is a number (Terrapin/Krell and TI Logo use NUMBER?)	x	x	x
OUTDEV	directs output to a device connected to Logo through an Apple peripheral card (Apple Logo uses .PRINTER)	x	x	
OUTPUT	causes a procedure to end and return a value to its caller	x	x	x
PA *	prints all procedures and names in the workspace (Apple Logo uses POALL; Terrapin/Krell Logo uses PRINTOUT ALL)	x	x	x
PACKAGE	puts a list of procedures into a named package	x		
PADDLE	returns the numeric value associated with a paddle (TI Logo uses JOY)	x	x	x
PAUSE	suspends execution of an executing procedure and allows user to interact with Logo from the keyboard (TI Logo uses the Aid key)	x	x	x
PKGALL	puts everything not already in a package into a named package	x		
PLIST	returns the property list of an object	x		
PN *	prints all the names in the workspace (Apple Logo uses PONS; Terrapin/Krell Logo uses PRINTOUT NAMES)	x	x	x
PO	prints a given procedure (Apple Logo can print several procedures; Terrapin/Krell Logo also uses PRINTOUT)	x	x	x
POPS *	prints the definitions of all procedures (Terrapin/Krell Logo uses PRINTOUT PROCEDURES)	x	x	
POTS *	prints all the procedure names in the workspace (TI Logo uses PP; POTS stands for "print out titles")	x	x	x
PPS *	prints all the property lists (stands for "print out properties")	x		
PRIMITIVEP	returns true value if the object is a Logo primitive	x		
PRINT	prints what follows and begins a new line	x	x	x
PRINT1	prints what follows without beginning a new line (TI and Apple Logos use TYPE)	x	x	x
PRINTCHAR	prints the character with a given number value			x
PRODUCT	calculates the product of two numbers	x		x
QUOTIENT	calculates the integer portion of the quotient of two numbers	x	x	x
RANDOM	generates a random number between 0 and *n* (TI Logo always generates an integer between 0 and 9)	x	x	x

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Nongraphics Commands

		Apple Logo	Terrapin/ Krell Logo	TI Logo
RANDOMIZE	randomizes the values of all future calls to RANDOM; RANDOMIZE *n* sets up a repeatable set of values		x	
READCHAR	waits for a keypress, returns its numeric value (Terrapin/Krell Logo uses READCHARACTER)	x	x	x
READLINE	takes all data typed in up to a carriage return and stores it as a list (Apple Logo uses READLIST; Terrapin/Krell Logo uses REQUEST)	x	x	x
READPICT	reads a picture file from the disk		x	
RECYCLE	performs a garbage collection to regroup unused nodes into one area (Terrapin/Krell Logo uses .GCOLL)	x	x	
REMAINDER	returns the remainder of a division operation	x	x	
REMPROP	removes a property from an object	x		
REPARSE	re-analyzes procedures in a workspace after other procedures have been erased	x		
REPEAT	executes a list a given number of times	x	x	x
RERANDOM	causes the RANDOM function to behave in a reproducible way (Terrapin/Krell Logo uses RANDOMIZE)	x	x	
ROUND	returns the input number rounded to the nearest integer	x	x	
RUN	executes the actions specified in a list	x	x	x
SAVE *	stores data or procedures on disk (TI Logo can also store to a cassette tape; Terrapin/Krell Logo can save entire workspace only)	x	x	x
SAVEPICT	saves the current graphics image on disk		x	
SENTENCE	joins two or more inputs (words or lists) into a list	x	x	x
SETDISK	specifies drive, slot, and volume number of active disk	x		
SHOW	prints the given object followed by a carriage return	x		
SIN	returns the sine of a given input (in degrees)	x	x	
SQRT	returns the square root of a given input	x	x	
STOP	stops a procedure	x	x	x
SUM	returns the sum of two numbers (Apple Logo can take more than two inputs)	x		x
TEST	evaluates a condition, influences execution of subsequent IFFALSE or IFTRUE command	x	x	x
TEXT	returns a list that contains the contents of a procedure	x	x	x
THEN	marks action taken if the conditional expression of an IF statement is true (Apple Logo uses brackets in place of THEN keyword)	x	x	x
THING	returns the value of the input object	x	x	
THING?	returns true value if input object has a value		x	x
THROW	user-defined error-trapping word	x		
TO	begins the definition of a procedure	x	x	x
TOPLEVEL	aborts all executing procedures (Apple Logo uses THROW "TOPLEVEL)	x	x	
TRACE	causes Logo to single-step through execution of all following Logo procedures until NOTRACE is executed		x	
TRACEBACK	if a program is paused, this command shows the user the nesting of procedures to get to the point at which the program is paused; a debugging aid			x
UNBURY	cancels the effect of a previous BURY command	x		
WAIT	pauses the program for a specified time	x		x
WORD	joins two numbers/words to make a single number/word	x	x	x
WORDP	returns true value if its input is a word (Terrapin/Krell and TI Logo use WORD?)	x	x	x
.BPT	exits to the Apple monitor	x	x	
.CALL	transfers control to a user-supplied machine-language subroutine		x	
.CONTENTS	outputs a list of information about all the items in the workspace	x		
.DEPOSIT	"pokes" a value from 0 to 255 in a specified memory location	x	x	
.EXAMINE	"peeks" the 8-bit value in a specified memory location	x	x	
Graphics-related commands				
BACK	moves the turtle backward	x	x	x
BACKGROUND	(Apple Logo) returns the color number of the current background	x		
BACKGROUND	(Terrapin/Krell Logo) sets the background to a given color (Apple Logo uses SETBG; TI Logo uses COLORBACKGROUND)	x	x	x
BACKGROUND	(TI Logo) names the background of the screen as object being talked to			x
CARRY	tells a sprite which object to carry (LOOKLIKE is a synonym in TI Logo)			x
CLEAN	clears the screen of turtle graphics but doesn't move the turtle (Terrapin/Krell Logo uses CLEARSCREEN)	x	x	
CLEARSCREEN	changes video display to turtle graphics screen, clears screen, and initializes turtle (TI Logo uses TELL TURTLE; Terrapin/Krell Logo uses DRAW)	x	x	x
CLEARTEXT	clears the text screen (TI Logo uses CLEARSCREEN)	x	x	x
COLOR	returns the color number of the sprite currently being talked to			x
CURSOR	(Apple Logo) returns the position of the cursor	x		
CURSOR	(Terrapin/Krell Logo) puts the text cursor at the given location (Apple Logo uses SETCURSOR)	x	x	

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Graphics-related Commands

Command	Description	Apple Logo	Terrapin/ Krell Logo	TI Logo
DOT	puts a dot at the indicated point on the turtle graphics screen	x		x
DRAW	clears the graphics screen, makes the turtle visible, and puts it in the center of the screen		x	
EACH	allows a set of commands to be applied to each of a group of sprites, in turn			x
FENCE	tells turtle to draw without wraparound—gives error message if turtle tries to plot offscreen (Terrapin/Krell Logo uses NOWRAP)	x	x	
FORWARD	moves the turtle forward	x	x	x
FREEZE	stops all sprite movement			x
FULLSCREEN	devotes entire screen to graphics (no text lines at bottom)	x	x	
HEADING	returns the heading number of the active sprite or turtle	x	x	x
HIDETURTLE	makes the triangular turtle shape disappear	x	x	x
HOME	tells active turtle or sprite to go to center of screen	x	x	x
LEFT	turns turtle or sprite left a given number of degrees	x	x	x
MAKECHAR	allows user to redefine the shape of a given character (tile)			x
MAKESHAPE	allows user to redefine the shape of a given sprite			x
NODRAW	returns the entire video display to display of text (Apple Logo uses TEXTSCREEN; TI Logo uses NOTURTLE)	x	x	x
NUMBEROF	allows user to check current value of a system variable (color, speed, etc.)			x
PEN	returns values for pen type and color	x		
PENCOLOR	(Apple Logo) returns value of pen color	x		
PENCOLOR	(Terrapin/Krell Logo) sets the current turtle pen color (Apple Logo uses SETPC)	x	x	
PENDOWN	makes the turtle pen ready to draw a line	x	x	x
PENERASE	makes the turtle pen ready to erase a line	x		x
PENREVERSE	makes the turtle pen ready to reverse a line (draws if line isn't there, erases if it is; Terrapin/Krell Logo must use PENCOLOR 6 to get same effect)	x	x	x
PENUP	makes the turtle pen inactive	x	x	x
POS	returns the position of the turtle (TI Logo uses WHERE)	x		x
PUTTILE	places a given tile (character) at a given location			x
RIGHT	turns a turtle or sprite right a given number of degrees	x	x	x
SCRUNCH	returns the current horizontal-to-vertical aspect ratio for output to the video screen	x		
SETCOLOR	tells a sprite, tile (character), background, or the turtle's pen what color to be			x
SETHEADING	gives the active sprite or turtle a given heading	x	x	x
SETPEN	sets color and type of turtle pen	x		
SETPOS	moves the turtle to a new position (TI Logo uses SXY, which can also move sprites; Terrapin/Krell uses SETXY)	x	x	x
SETSCRUNCH	sets a new horizontal-to-vertical video display aspect ratio (Terrapin/Krell Logo uses .ASPECT)	x	x	
SETSPEED	gives the active sprite a given speed			x
SETX,SETY	moves turtle to given x- or y-coordinate, other coordinate unchanged (TI Logo uses SX and SY, which can also move sprites)	x	x	x
SHAPE	returns the shape number of the active sprite			x
SHOWNP	returns true value if turtle is visible	x		
SHOWTURTLE	makes the triangular turtle shape appear	x	x	x
SPEED	returns the speed value of the active sprite			x
SPLITSCREEN	removes bottom area of graphics screen for text area	x	x	
SPRITE	optional word used with TELL to name a given sprite as the object being talked to			x
SV	sets the x- and y-velocity of the active sprite			x
SXV,SYV	gives the active sprite a new x- or y-velocity			x
TELL	used to activate a sprite, group of sprites, tile (character), background, or turtle to respond to future commands			x
THAW	restores sprite movement after FREEZE command			x
TILE	used with TELL to make a given tile active			x
TOWARDS	returns heading value turtle would have if it were pointing toward a given position	x	x	
TURTLE	used with TELL to make the turtle active			x
TURTLESTATE	returns pen position, turtle status, background color, and pen color		x	
WHO	gives the type and number of the active object (tile, sprite, turtle, etc.)			x
WINDOW	allows the turtle to plot offscreen (although the plotting can never be seen)	x		
WRAP	causes the turtle to appear on the opposite side of the screen if it attempts to go offscreen	x	x	
XCOR,YCOR	returns the x- or y-coordinate of the active sprite or turtle	x	x	x
XVEL,YVEL	returns the x- or y-velocity of the active sprite			x
YOURNUMBER	returns the number of the active sprite			x

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Test # (see caption)	Time to Execute, in Seconds, When Running:		
	Apple Logo	Terrapin/Krell Logo	TI Logo
Test 1	6.2	7.0	14.9
Test 2	4.5	5.0	N/A

Table 4: *Timing benchmarks of three implementations of Logo. The program being timed in test 1 is the Logo command* SORT [LOGO IS AN INTERESTING LANGUAGE FOR PICTURE DRAWING, LIST MANIPULATION, AND EDUCATION]. *The program being timed in test 2 is* SORT [Z Y X W V U T S R Q P O N M L K J I H G F E D C B A]. *See listing 2 for the definition of* SORT. *The N/A under TI Logo for test 2 refers to the fact that TI Logo did not finish this test; it gave the error message* OUT OF SPACE AT LEVEL 23 LINE 1 OF SORT. *The times, given in seconds, are accurate to two significant digits. Also, the comments were taken out of the procedures before the benchmarks were run.*

Text continued from page 278:

than it is here. All the Apple- and TI-based versions of Logo are products of higher caliber than what we're used to seeing in the microcomputer software industry.

If you don't already have a computer, then your choice of computer will be influenced by such questions as: How much money do I have to spend? What things other than Logo do I want to do with this computer? What kind of person will be using Logo? and Do they have any special needs that would influence my choice? If you already have an Apple computer and don't know which version of Logo to buy, your choice will be influenced by the individual features of each version and how they relate to the intended users and programmers. (My own opinion is that Apple Logo is better for situations involving nontechnical users and that Terrapin Logo is oriented more toward the sophisticated programmer.)

Conclusions

Apple Logo is a very well done implementation of Logo. It contains some advanced features (such as property lists and packages) as well as extremely good documentation and features that are oriented toward usage by children or adults who don't have technical backgrounds. Several features—including its unnecessary use of Logo command inputs in list form and its lack of provision for comments—are not consistent with this orientation and may cause nontechnical users some problems at first. A sprite board will probably be available from the implementers of Apple Logo, Logo Computer Systems Inc.

Terrapin/Krell Logo is also very well done. It includes such advantages as a Utilities Disk with useful programs, a 6502 assembler, and the ability to interface Terrapin/Krell Logo with assembly-language routines. It has a program-tracing function that is *very* useful during debugging, and its editor and error messages are slightly better than those of Apple Logo. The documentation is very good, and a sprite board (probably cheaper than Apple Logo's but with somewhat different features) will be available. Your choice of Krell or Terrapin Logo will depend on the factors mentioned in the text of this article.

TI Logo is a good implementation of Logo, but it is not as good as the Apple versions. Its advantages are its low cost, sprites, and tiles; disadvantages include a smaller workspace and slower execution than in the Apple-based Logos, poor keyboard layout, and some irregularities in the system caused by poor design decisions. ■

A General-Purpose I/O Board for the TRS-80 Models I and III

The system bus is described, and plans are presented for an interface board with 24 lines of discrete input/output.

William Barden Jr.
28122 Orsola
Mission Viejo, CA 92692

Several months ago (June 1982 BYTE, page 260) I described a general-purpose input/output (I/O) board for the TRS-80 Color Computer. This month I'll describe its counterpart, a general-purpose I/O board for the TRS-80 Model I and Model III. As I imagine that few of you have both a Color Computer and a Model I or III and perhaps some did not read the earlier article, I'll give you the details on the logic of the board, even though it is very similar to the Color Computer version. I'll also describe the internal workings of the Model I/III system bus, which is quite a bit different from the Color Computer bus. And I'll give you the story on the slight differences between the Model I and III buses in the way the external I/O is connected.

The System Bus

It's true the Model I/III system bus is closely related to the Z80 microprocessor signals, although the Z80's manufacturer, Zilog, might not speak of it in mixed company. To describe the Model I/III system bus, therefore, I have to start with the Z80 signals.

Figure 1 on page 292 shows a general block diagram of the TRS-80 Model I system bus. In the following discussion, I'll talk about the Model I bus and then describe the Model III bus, which has some embellishments.

Model I bus. The Z80 has 16 address lines, labeled A15 through A0, most significant to least significant. The address lines are used to address RAM (random-access read/write memory), ROM (read-only memory), and I/O devices. The 16 address lines allow the Z80 to address 64K bytes of memory and 256 I/O devices.

Perhaps I'd better explain that the Z80 can use both memory-mapped and input/output-mapped I/O. Input/output-mapped I/O means that the Z80 has separate instructions (IN and OUT) for input/output, allowing all of the 64K-byte addresses to be used for memory if the system designer chooses. Input/output is specified by certain control signals that inform an external I/O device when an IN or OUT machine-language instruction, rather than a "memory-reference" instruction, is being executed.

Memory-mapped I/O is used in computers based on chips like the 6502 and 6809. A portion of the 64K-byte address space is dedicated to I/O addresses, and there are no control signals to indicate that input/output is being performed. To the processor, an input/output operation looks just like reading or writing data into memory. Of course, the system designer allocates certain addresses to memory and certain addresses to input/output devices, and the programmer works with this allocation in mind at all times.

The Models I and III were designed with both memory-mapped I/O and input/output-mapped I/O, as shown in figure 2. The keyboard, for exam-

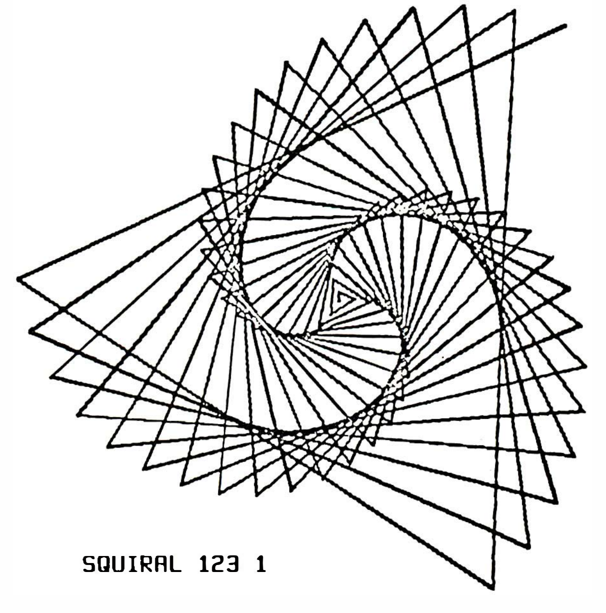
Text continued on page 294

About the Author
William Barden Jr. has written numerous books on microcomputer design and programming, including Microcomputer Math.

Figure 1: *The system bus for the Model I is made up of 40 lines, very closely related to Z80 signals. Sixteen are address lines, eight are data bus lines, four are control signals for external devices, and the remainder are related to memory refresh, interrupt operations, and miscellaneous functions.*

The Logo Language is Here for the Apple II

```
TO SQUIRAL :ANGLE :DISTANCE
 IF :DISTANCE > 200 THEN STOP
 FORWARD :DISTANCE
 RIGHT :ANGLE
 SQUIRAL :ANGLE :DISTANCE + 3
END
```



Terrapin, the Turtle Company, brings you the Terrapin Logo Language for the Apple II with Turtle graphics, now ready for immediate delivery.

The Terrapin Logo language is a sophisticated and powerful language that is easy for anyone to use. Although originally intended for children, the Logo language is one that the most advanced programmers will enjoy using too. It includes many features common to artificial intelligence research languages permitting programs of great power to be written quickly and easily. Writing comparable programs in other languages is usually much more difficult and time consuming.

The Turtle graphics is fun and easy. With simple commands such as FORWARD, RIGHT, and PENUP you can draw in six hi-res colors. In just a few short sessions you can learn to create figures more complex than the one above whether you know how to program or not.

But the Terrapin Logo language is more than just a graphics language. It supports:

- list structure, allowing easy manipulation of words (strings) and lists
- user defined procedures which can be used exactly as if they were part of the language.
- fully integrated screen editor for procedures and text
- floating point and integer arithmetic
- a total of 120 primitives (commands) including 30 graphics commands
- recursion
- assembly-language interface capability

The Terrapin Logo language was developed by the Artificial Intelligence lab at the Massachusetts Institute of Technology. Terrapin is now authorized by MIT to distribute the results of its 12 years of research to you. To provide quality support for the language, Terrapin has assembled a team that includes two of the three authors who developed the Logo language for the Apple II at MIT, as well as Dr. Feurzeig, an originator of the Logo language.

Every copy of the Terrapin Logo language comes with complete documentation. To run the language, a 48K Apple II with a 16K RAM card or a language card, and one disk drive is required.

Terrapin also offers the robot Turtle, and the following books: *Turtle Geometry, Special Technology for Special Children, Mindstorms, Katie & the Computer,* and *Logo for the Apple II* from Byte Books.

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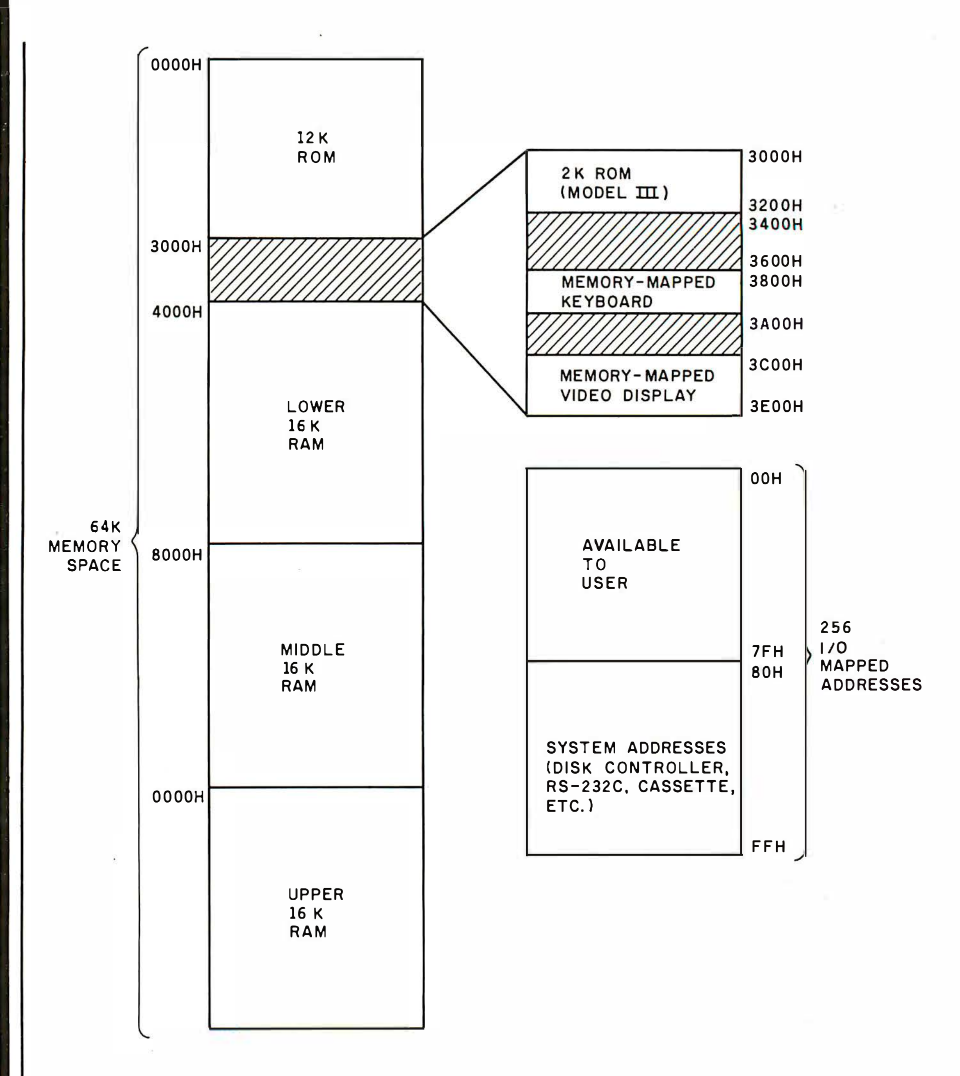


Figure 2: *The Models I and III have 64K bytes of addressing space. Some system devices are memory-mapped and use dedicated addresses within the 64K bytes. Other system devices use the I/O-mapped addresses hexadecimal 0 through FF.*

Text continued from page 291:

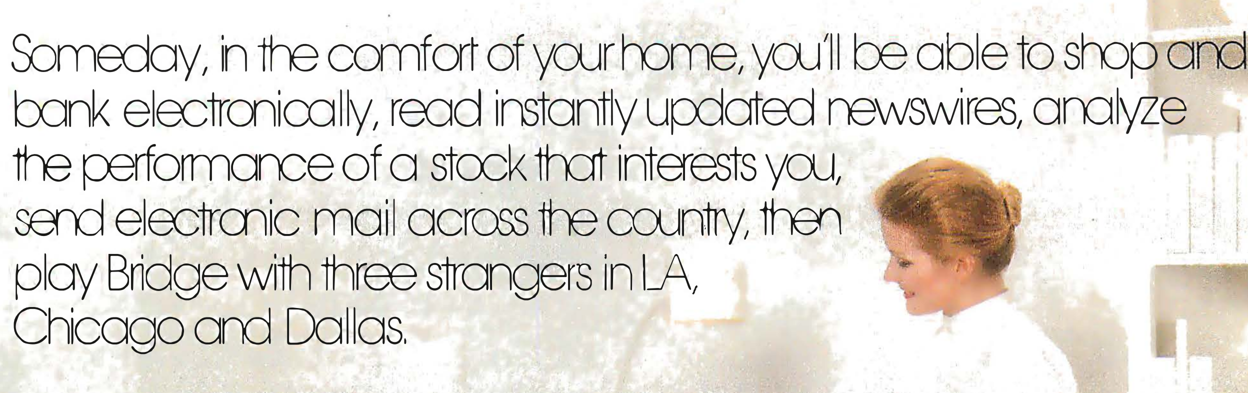
ple, is memory-mapped at memory locations hexadecimal 3801 through 3880; the cassette is I/O-mapped at hexadecimal location FF. I/O-mapped operations use separate IN or OUT instructions with I/O addresses of hexadecimal 0 through FF; these I/O ports are completely separate from the 64K-byte memory.

The 16 address lines are buffered by 74LS367 bus drivers to provide higher fan-out; they go out to all parts of the Model I, including the external 40-pin connector for the system bus. The address lines are unidirectional, that is, they are outputs only from the Z80.

Back to the Z80 signals. The next largest set of signals is the data bus, which is Z80 signals D7 through D0, most significant through least significant. The data bus is used to pass all data going between Z80 registers and memory and between Z80 registers and I/O devices.

Unlike the address bus, the data bus is bidirectional, permitting 8-bit transfers in both directions. Two sets of 74LS367 bus drivers are used, one controlled by a "data bus out" signal DBOUT*, and the other controlled by a "data bus in" signal DBIN*. (The asterisk is used in all Model I/III circuit discussions to indicate "active low.") The data bus lines also go to the 40-pin system bus connector on the Model I.

Looking at the Z80 once again, you



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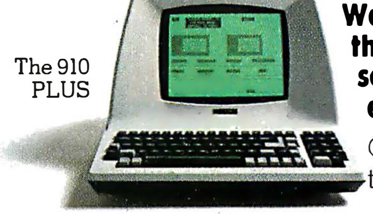
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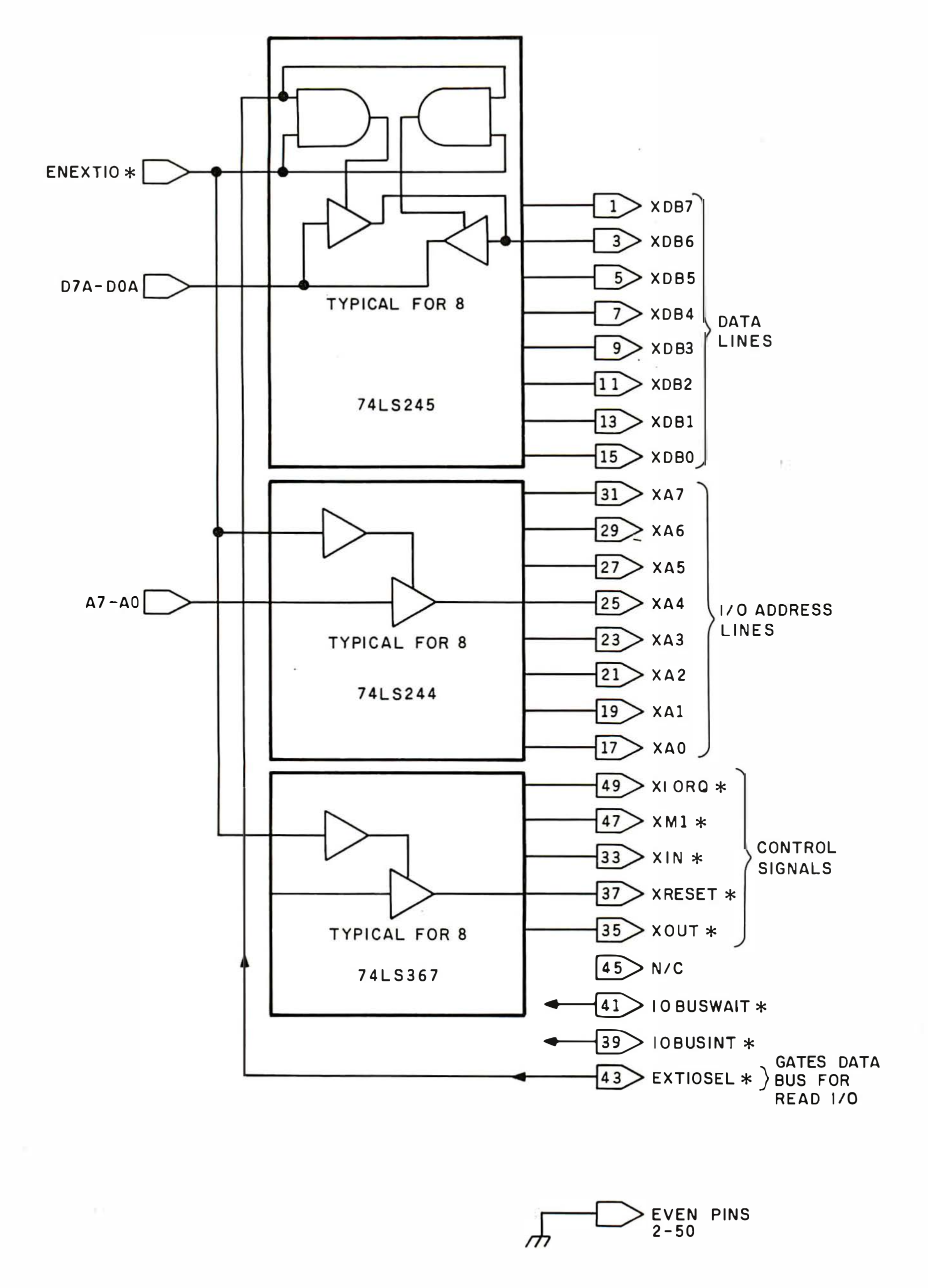


Figure 3: *The system bus for the Model III is similar to the Model I system bus. Only eight address lines are brought out, however, and the address, data, and control lines are enabled by an "external I/O" signal, which must be set under program control.*

find two sets of control signals: $\overline{MREQ}$/$\overline{IORQ}$ and $\overline{WR}$/$\overline{RD}$. Signal $\overline{MREQ}$ (the bar indicates a Z80 "active low" signal) is used to indicate that a memory operation is in effect and that there is a valid memory address on address lines A15 through A0. $\overline{MREQ}$ is used with $\overline{RD}$ to read data from ROM or RAM and with $\overline{WR}$ to write data to ROM or RAM. $\overline{MREQ}$ is also used for memory-mapped I/O devices, such as the keyboard.

Signal $\overline{IORQ}$ is used to indicate that an IN or OUT instruction is being executed and that there is an I/O address on address lines D7 through D0. $\overline{IORQ}$ is used with $\overline{RD}$ to read data into the Z80's A register from an external I/O device and to write data from the A register to an external I/O device. $\overline{IORQ}$ is the primary signal used for all types of I/O-mapped input/output.

The signals brought out on the system I/O bus, however, are not $\overline{MREQ}$, $\overline{IORQ}$, $\overline{WR}$, and $\overline{RD}$. The RD* signal is active (low) when $\overline{RD}$ and $\overline{MREQ}$ are active (during a memory read). The WR* signal is active (low) when $\overline{WR}$ and $\overline{MREQ}$ are active (during a memory write). The IN* signal is active (low) when $\overline{IORQ}$ and $\overline{RD}$ are active (input). The OUT* signal is active (low) when $\overline{IORQ}$ and $\overline{WR}$ are active (output). Then, these signals are partially encoded for external memory or input/output.

Other memory-related signals brought out on the system bus for "memory refresh" are MUX, CAS*, and RAS*. These three signals control memory refresh for the dynamic RAM chips used in the Model I and III. Since they're not used in external I/O, I'll omit any further details.

Other signals brought out on the Model I bus include INT*, INTAK*, TEST*, WAIT*, and SYSRES*.

INT* is an input and provides an external I/O interrupt. INTAK* is an "interrupt acknowledge" signal that indicates the Z80 received the interrupt.

TEST* is a signal that disables all data bus, address bus, and control signals; it is rarely used in Model I operations.

WAIT* is an input signal used to interface slow memory or I/O devices and is not ordinarily used. It dates from the time when memories were significantly slower than the microprocessor.

SYSRES* is an output signal that indicates power-up or reset (by the RESET button). It, like all of the signals with an asterisk suffix, is active low.

Model III system bus. Figure 3 shows a general block diagram of the Model III system bus, which differs from the Model I system bus in that it is more isolated from the internal processor signals. Only eight address lines are brought out, and a special "enable" signal gates the data, address, and control lines to the outside world.

The main enable signal is ENEXTIO*, which means enable external I/O. This signal is generated by 1 bit of a 5-bit latch with port address hexadecimal EC. When this bit is a 1, signal ENEXTIO* goes low, enabling the 74LS245 (XDB7 through XDB0),

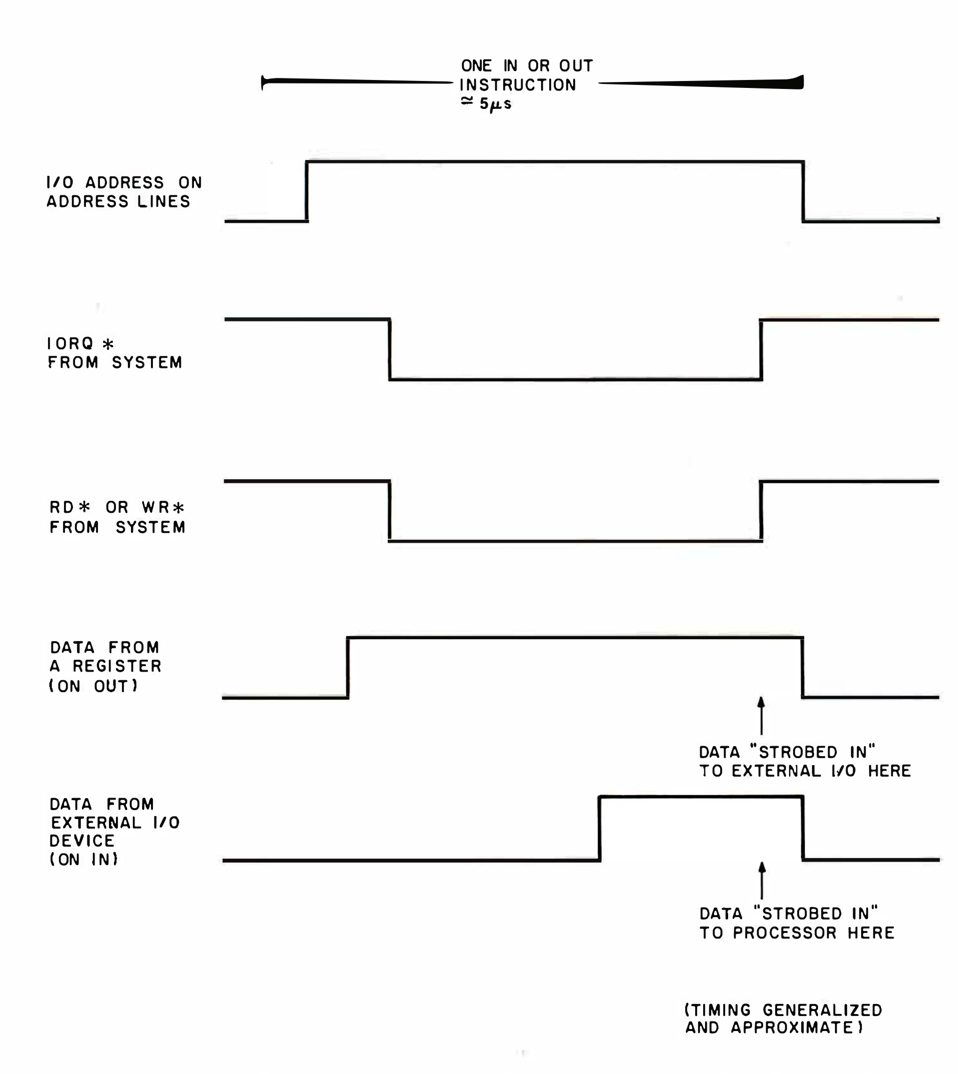


Figure 4: *External I/O operations use an I/O address on the address bus, the IORQ* signal, and the RD* or WR* signal to effect 8-bit data transfers to and from the external I/O device.*

the 74LS244 (XA7 through XA0), and the 74LS367 (control lines). If the ENEXTIO* bit is a 0, all of these lines are in the high-impedance (disconnected) state.

The XIORQ*, XM1*, IOBUSWAIT*, XRESET*, XOUT*, and XIN* control lines have the same functions as their Model I counterparts—WAIT*, SYSRES*, OUT*, and IN*. (IORQ* and M1* replace the encoded INTACK*.)

The IOBUSINT* is similar to INT* in the Model I, except that an enable signal, ENIOBUSINT (enable I/O bus interrupt), is used to determine when an external interrupt will be recognized from the outside world. ENIOBUSINT is made active by writing a 1 to bit 3 of port address hexadecimal E0. I won't discuss the external interrupts in this article, as they make an interesting subject all by themselves.

The eight address lines are also logically equivalent to their Model I counterparts; they are XA7 through XA0.

The eight data bus lines XDB7 through XDB0 have a slightly different gating scheme on the Model I from that on the Model III. Instead of two sets of buffers enabled by RD* or WR*, as in the Model I, there is one bus driver, a 74LS245. The main enable signal for this chip is ENEXTIO*, as I've already mentioned. Also involved, though, is signal EXTIOSEL*. When EXTIOSEL* is a 1, the 74LS245 routes lines D7A through D0A to the external bus connector. When EXTIOSEL* is a 0, the 74LS245 routes lines from the external bus to lines D7A through D0A. EXTIOSEL* is normally high, allowing writes to an external I/O device to be made by simply turning on ENEXTIO* (address hexadecimal EC) and performing a Z80 OUT instruction (or a BASIC OUT). If a read of an external device is to be done, however, external logic must bring down signal EXTIOSEL* at the proper time.

General Scheme for External I/O

The general scheme for Model I external I/O is fairly simple.

Output operation. The procedure for a write of 8 bits to an external device is as follows:

1. The 8-bit value to be written (0 through 255) is put into the A register in the Z80.
2. A machine-language OUT instruction with an address of 0 through 255 is executed.

The equivalent in BASIC is:

```
100 OUT XX,V
```

where XX is the I/O address and V is the value of 0 through 255.

Executing the machine-language or BASIC OUT puts the address of the I/O device on address lines A7 through A0 and enables the OUT* signal. The external I/O device decodes the address lines when it receives the OUT* signal. If the external I/O device recognizes its address, it strobes in the data that is present on the data bus lines. The entire process is shown in figure 4.

Output for the Model III is identical, except that the external I/O lines must first be enabled by setting bit 4 of address hexadecimal EC to enable signal ENEXTIO*.

Input operation. Input for the Model I is the following:

1. A machine-language IN or a BASIC INP instruction is executed, with an address of 0 through 255.
2. Data from the input/output device is read into the A register or into the BASIC variable specified. The BASIC equivalent is 100 A=INP(XX).

When the machine-language IN or BASIC INP is executed, the address of the I/O device is sent to the address bus lines A7 through A0. Signal OUT* goes low, indicating to the external I/O logic that an I/O address is present on the address lines. If the address is decoded as the address of the I/O device, it responds by gating the 8 bits of data onto the data bus.

Input for the Model III is identical, except that the external I/O logic must also bring down signal EXTIOSEL* so that the 74LS245 bus driver switches direction, routing the data to the processor.

I/O addresses. The I/O port address used must be in the range of 0 through 127 because I/O addresses 128 through 255 are dedicated-system addresses in Models I and III. There are many addresses not used in the higher range, but it's prudent to stay below 128 to avoid conflict. External I/O can be done without full address-decoding logic.

A General-Purpose I/O Board

The circuit shown in figure 5 is a general-purpose input/output (GPIO) board that connects to the Model I or III system bus. It provides 24 I/O lines that can be either inputs or outputs. The lines can be used to drive relays for input or output as shown in the figure, to implement digital-to-analog or analog-to-digital converters, or for a variety of other applications. I'll describe how the circuit works, give you some construction hints, and then show you typical uses in driving an LED (light-emitting diode) display and detecting a remote input.

The GPIO board uses an Intel 8255 Programmable Peripheral Interface, which is essentially a programmable controller. The mode that I am using in this implementation connects lines PA7 through PA0 and PB7 through PB0 as outputs and lines PC7 through PC0 as inputs.

The interface to the Model I or III consists of the eight data bus lines, three address lines, the IN* and OUT* lines, and in the case of the Model III, the EXTIOSEL* line. The IOBUSINT* line is also implemented but won't be described in this article.

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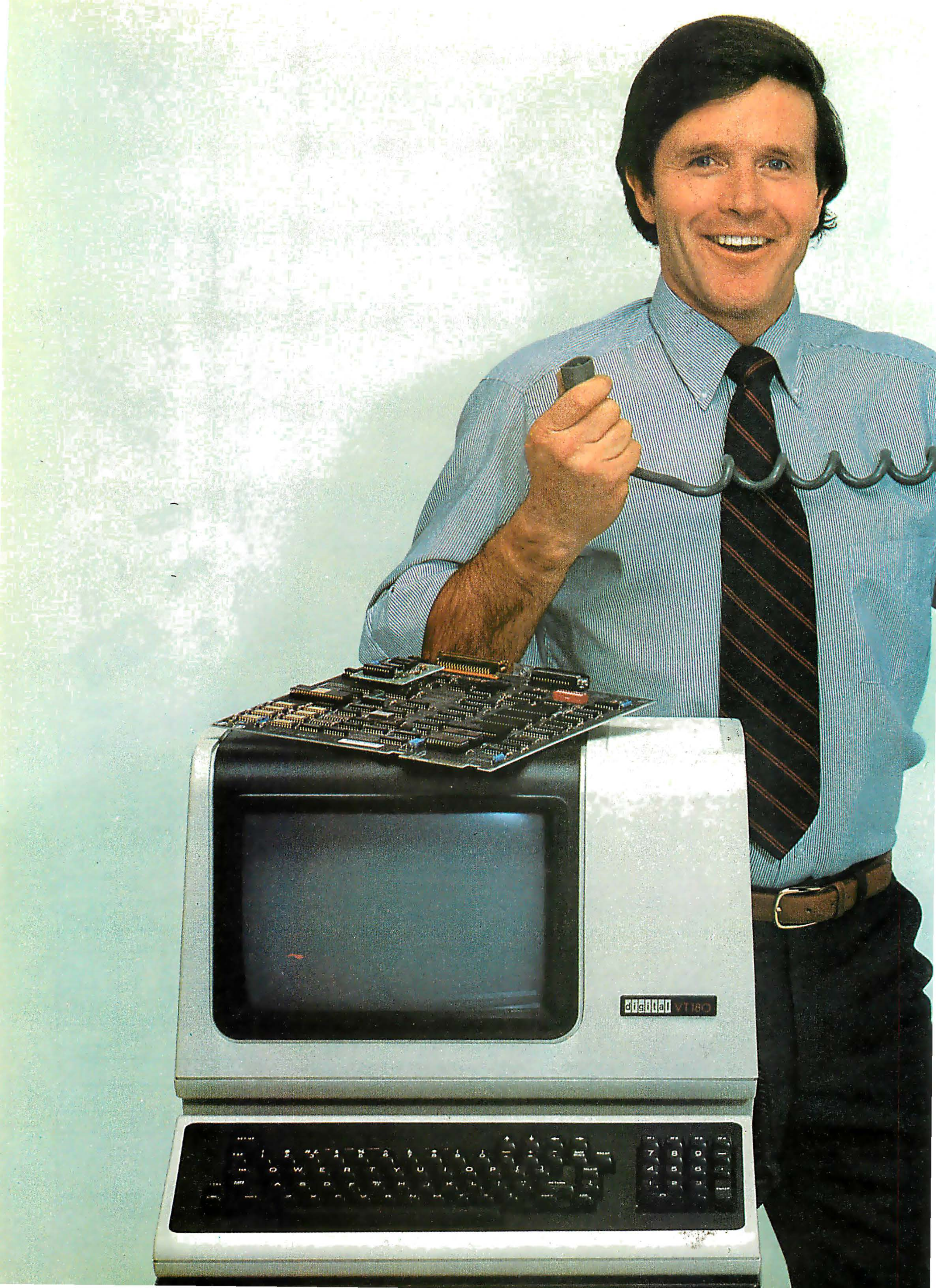
Name

Address

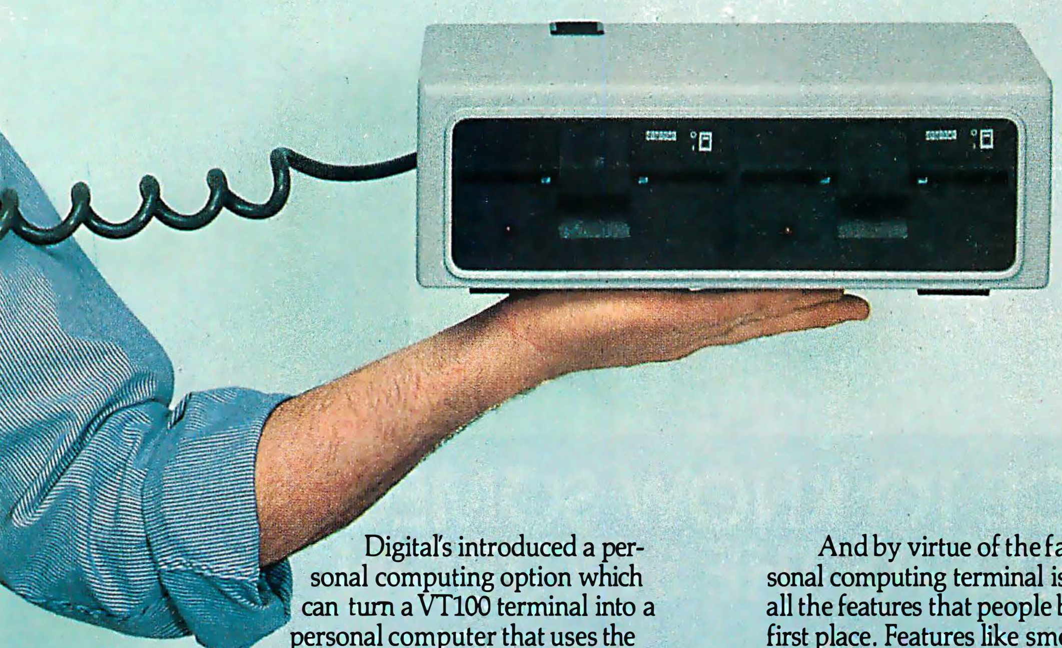
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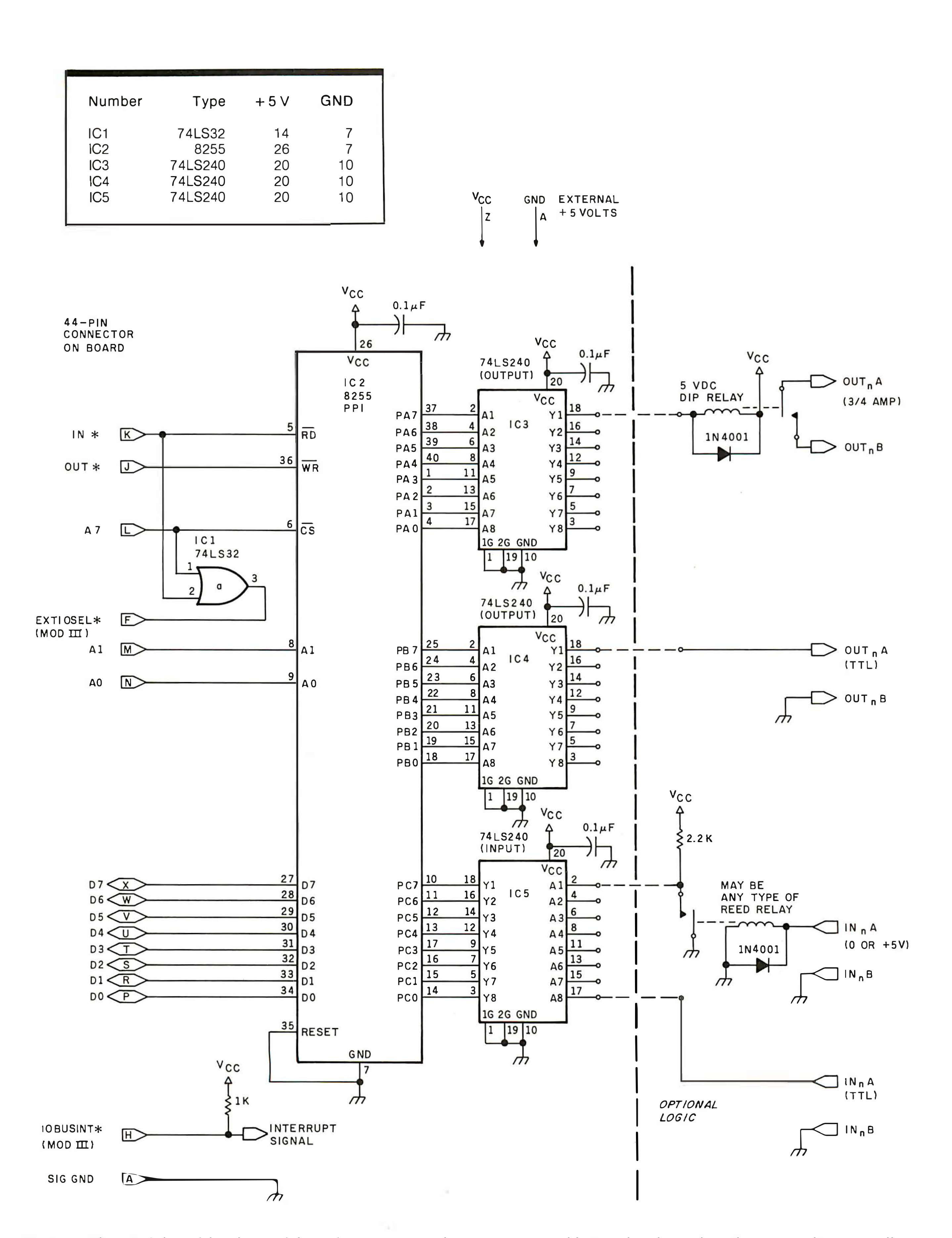
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Number	Type	+5 V	GND
IC1	74LS32	14	7
IC2	8255	26	7
IC3	74LS240	20	10
IC4	74LS240	20	10
IC5	74LS240	20	10

Figure 5: *The GPIO board for the Model I and III uses an Intel 8255 Programmable Peripheral Interface chip as a 24-line controller. Sixteen of the lines are outputs and control 74LS240 drivers. Eight of the lines are inputs.*

← Circle 257 on inquiry card.

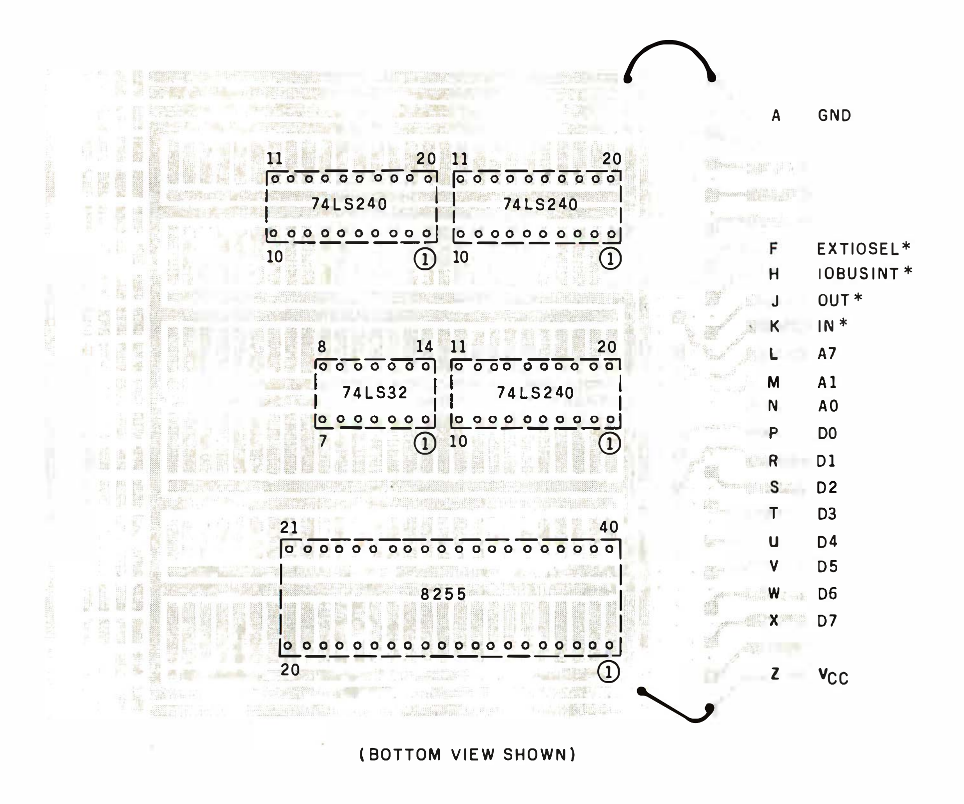


Figure 6: *The GPIO is built on a standard prototype board using wire-wrap IC sockets.*

The address of the GPIO is any four sets of addresses in the lower I/O address range of 0 through 127. For convenience, you can look upon the addresses as 0, 1, 2, and 3, but the board will respond to any address with bit 7 equal to 0, ignoring bits 2 through 6. Address binary 01111100, for example, will be decoded the same as address 0.

The address of the latch associated with the PA lines (see figure 5) is address 0. Outputting data to address 0 will store the data pattern in the output and set the lines accordingly. The address of the latch associated with the PB lines is address 1. An identical type of output can be done for this latch. Address 2 controls the PC lines. Inputting data from this address will read the state of the eight lines.

The last address of the GPIO is address 3 (address binary *xxxxxx*11). This is the address of an internal control register in the 8255. Outputting a control word to address 3 configures the 8255. To get the configuration I've described, output a decimal 137. This needs to be done only once, at the beginning of any power-up sequence.

The normal sequence of events for using the GPIO is shown here:

```
100 'BASIC DRIVER FOR GPIO
110 OUT 236,16    'Model III only
120 OUT 3,137     'setup 8255
130 OUT 0,XX      'output to
                  PA7-PA0
140 OUT 1,XX      'output to
                  PB7-PB0
150 A=INP(2)      'read PC7-PC0
```

The first command sets the Model III EXTIOSEL*. (An important point: This command must be done at the start of any entry to a BASIC program and after any CLS command. When in doubt, issue another EXTIOSEL*.) The OUT 3,137 command sets the 8255 to the proper I/O configuration. The next two commands output a byte to the two output ports. The next command reads in the configuration of the PC7 through PC0 lines.

The 8255 lines are connected to three 74LS240 line-driver chips. These chips provide up to 10 milliamps (mA) of 5-volt (V) source current or 40 mA of 0-V sink current. The top two chips are connected as output drivers, and the bottom is an input driver.

GPIO Construction

The board is assembled on a Radio Shack prototype board (276-154). The board has a 44-pin connector on one end that mates with a Radio Shack plug (276-1551). The board will be identical for both the Model I and III version, but the cable for the plug will be different.

Socket mounting and wiring. Mount five sockets on the board, as shown in figure 6. I used wire-wrap sockets for this version. You may use solder-type sockets if you prefer, as there are not a great many interconnections. The sockets should straddle the two etches that represent the V_{CC} (+5 V) and GND buses. Solder opposing socket pins to hold the sockets to the board. Connect 0.1-μfd disk capacitors to the V_{CC} and GND buses close to each integrated-circuit (IC) socket.

The pins are numbered as shown in the figure and correspond to the connector pin numbering. Use pin A as GND and solder a short wire to the GND bus as shown. Use the pin Z, which is on the opposite end of the plug, as V_{CC} and solder as shown.

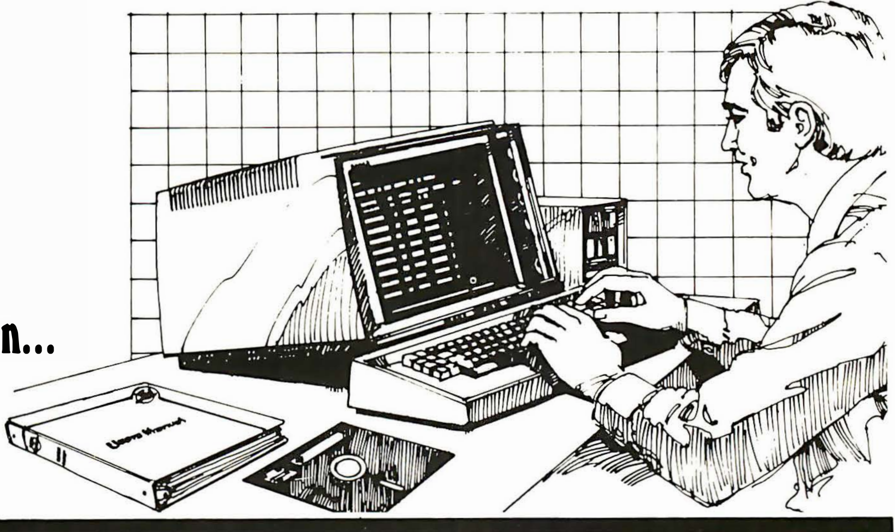
Wrap the sockets as shown in table 1. Figure 6 shows the bottom view of the board with correct pin numbering. CON-F, CON-M, etc., shown in table 1, relate to the pins labeled F, M, etc., in figure 6.

Checking the board wiring. After you've wired the board, check the wiring before plugging in any ICs. Two common pins fit nicely into the IC socket holes, as shown in figure 7.

Cable fabrication. If the *wiring* checks out, you're ready to fabricate the cable. There are two cables, one for the Model I and one for the Model III, as shown in figure 8. Two wires go from the 44-pin connector end of the cable to a +5 V supply, as shown in figure 9.

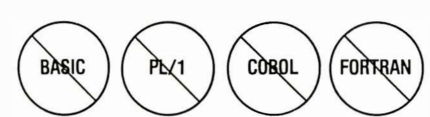
At one end of the cable, use the Radio Shack 44-pin connector. Solder the connections.

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CON-K	8255-5	IN*/RD
CON-J	8255-36	OUT*/WR
CON-L	8255-6	A7/CS
255-6	74LS32-1	A7/CS
255-5	74LS32-2	IN*/RD
CON-F	74LS32-3	EXTIOSEL*
CON-M	8255-8	A1
CON-N	8255-9	A0
CON-X	8255-27	D7
-W	-28	D6
-V	-29	D5
-U	-30	D4
-T	-31	D3
-S	-32	D2
-R	-33	D1
-P	-34	D0
CON-H	1-kΩ resistor	IOBUSINT*
1-kΩ resistor	V_{cc}	IOBUSINT*
8255-35	8255-7	RESET
CON-Z	V_{cc} bus	V_{cc}
CON-A	GND bus	GND
8255-37	74LS240-2	PA7
-38	-4	6
-39	-6	5
-40	-8	4
-1	-11	3
-2	-13	2
-3	-15	1
-4	-17	0
8255-25	74LS240-2	PB7
-24	-4	6
-23	-6	5
-22	-8	4
-21	-11	3
-20	-13	2
-19	-15	1
-18	-17	0
8255-10	74LS240-18	PC7
-11	-16	6
-12	-14	5
-13	-12	4
-17	-9	3
-16	-7	2
-15	-5	1
-14	-3	0

TO V_{cc} BUS:	TO GND BUS:
74LS32-14	74LS32-7
8255-26	8255-7
74LS240-20 (3)	74LS240-1 (3)
	74LS240-19 (3)
	74LS240-10 (3)

0.1 μF CAPACITORS BETWEEN:

V_{cc} and GND pins near IC sockets (5)

Table 1: *GPIO board wiring list. (CON-A, CON-F, CON-H, etc., are connection points in figure 6.)*

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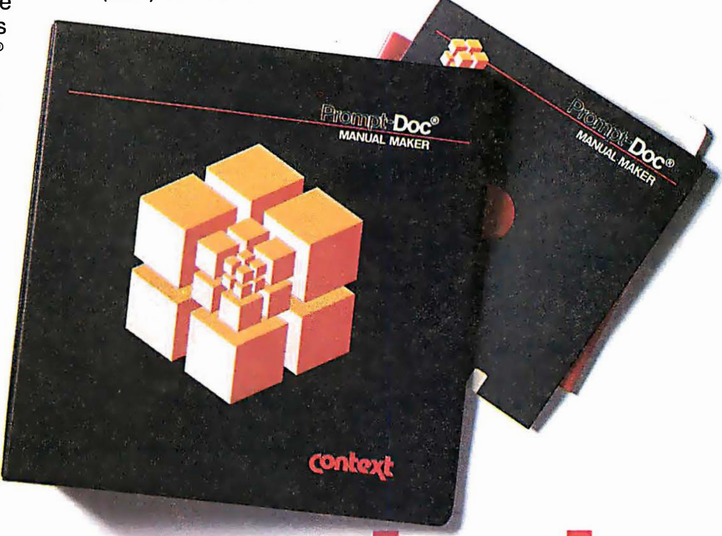
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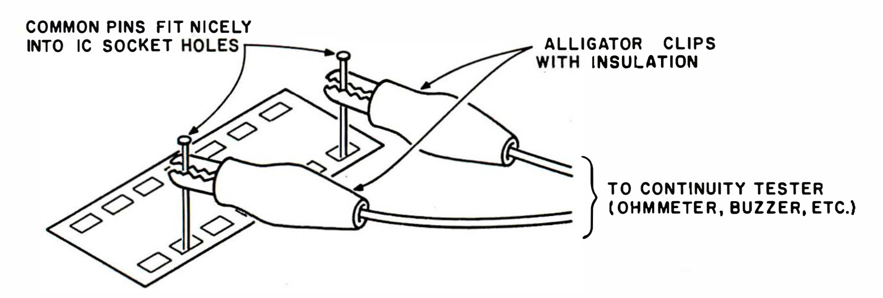


Figure 7: *After GPIO board fabrication, the wiring connections should be checked out. Two common pins and a continuity tester or ohmmeter facilitate checkout.*

PROTOTYPE BOARD CONNECTOR PIN	MODEL I PIN	MODEL III PIN	PROTOTYPE BOARD SIGNAL (PIN)
K	19	33	IN *
J	12	35	OUT *
L	36	31	A7
M	27	19	A1
N	25	17	A0
X	20	15	D7
W	24	13	D6
V	28	11	D5
U	18	9	D4
T	26	7	D3
S	32	5	D2
R	22	3	D1
P	30	1	D0
A	8	8	SIGNAL GROUND
A	(TO EXTERNAL GROUND)		SIGNAL GROUND
Z	(TO EXTERNAL +5 VDC)		V_{CC}
H	21	39	IOBUSINT *
F	NC	43	EXTIOSEL *

MODEL I — 39 37 TOP 3 1 / 40 38 4 2 (LOOKING IN TO EDGE CONNECTOR)

MODEL III — 1 3 FRONT 47 49 / 2 4 48 50 (LOOKING IN TO EDGE CONNECTOR)

NC= NO CONNECTION

Figure 8: *Cable wire list and edge connector orientation.*

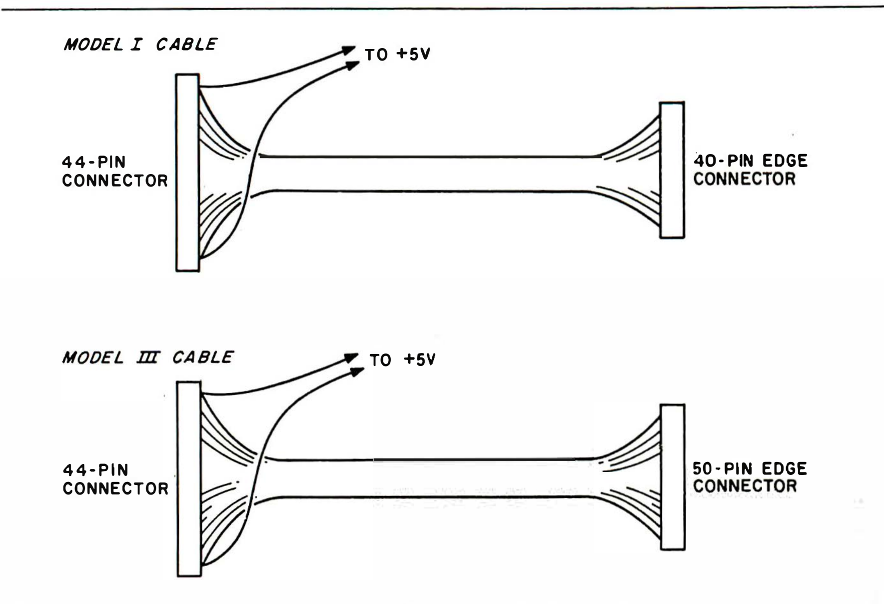


Figure 9: *The cable for the Model I is different from the Model III version. The Model I version uses a 40-pin edge connector, while the Model III version uses a 50-pin edge connector. Both versions use a 44-pin connector for the prototype board.*

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Listing 1: *Demonstration program for output and input for the Model III. Delete line 110 for the Model I version.*

```
100 'DEMO MODEL III PROGRAM FOR OUTPUT AND INPUT
105 CLS
110 OUT 236,16
120 OUT 3,137
140 PRINT @512+32,INP(2)
150 OUT 0,0
160 GOSUB 1000
170 OUT 0,255
180 GOSUB 1000
190 GOTO 140
1000 FOR I=0 TO 100
1010 NEXT I
1020 RETURN
```

At the other end, use a 40-pin edge connector (Radio Shack 276-1558) for the Model I or a 50-pin edge connector for the Model III. Be sure to use the numbering shown in figure 8 for the edge connectors. The Model III connector uses the reverse numbering from the Model I connector! Connections may be made using ribbon cable (and forcing the ribbon cable onto the connector) or by simply soldering 24-gauge stranded copper wire to the connector pins.

If you are using individual wires, use cable ties to band the wire together into a single cable.

Testing the GPIO. When you have "buzzed out" the cable, plug in the ICs, connect the cable to the board, and connect the power-supply leads to the +5 V supply. (Do not plug the cable into the computer at this point.) Make a "smoke test" by momentarily touching the chips. The 8255 should be warm but not hot.

Turn off all power and plug the other end of the cable into the Model I or III. The proper orientation is shown in figure 10.

Execute the BASIC program shown in listing 1. (Eliminate line 110 for the Model I version of the board.) This program "toggles" the outputs of PA7 through PA0 at a low speed rate and also reads lines PC7 through PC0.

Carefully test the outputs of the first 74LS240 by the method shown in figure 11. Of course, you may use a voltmeter, logic probe, or 'scope if you have one. You should see the output change from 0 V to +4 V or so and back again.

MODEL I
TOP
REAR
LEFT SIDE OF EXPANSION INTERFACE
1 39
2 40
FRONT
(CABLE)

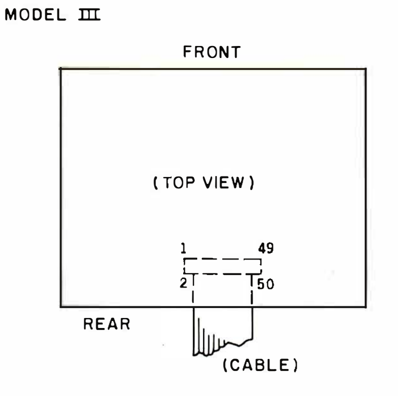


Figure 10: *Cable connection to the Model I or III.*

Inputs may be grounded by connecting the input pins of the third 74LS240 to ground. You should see a 128, 64, 32, 16, 8, 4, 2, or 1 value displayed on the screen, corresponding to the bit position of the pin grounded. The PB7 through PB0 outputs may be tested by substituting "OUT 1,0" and "OUT 1,255" for lines 150 and 170, respectively.

Typical Applications

To give you some flavor of how the GPIO board may be used, I've implemented a seven-segment LED display driver as shown in figure 12. The LED display used is a Radio Shack

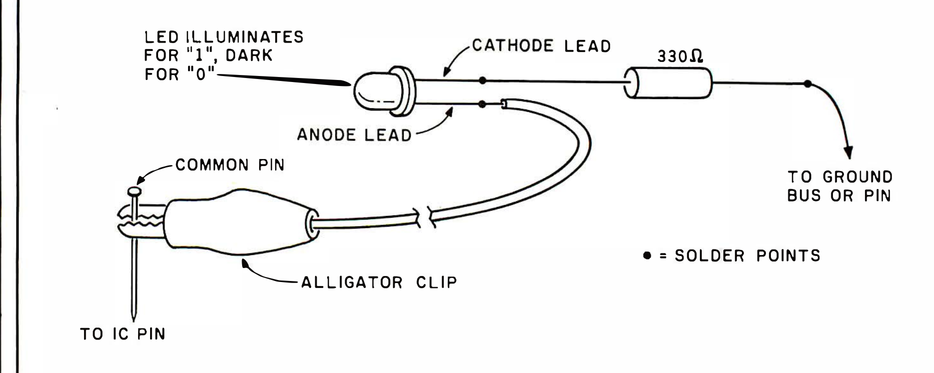


Figure 11: *After building the GPIO, the 24 lines may be tested easily by a LED/resistor tester for outputs and by grounding inputs.*

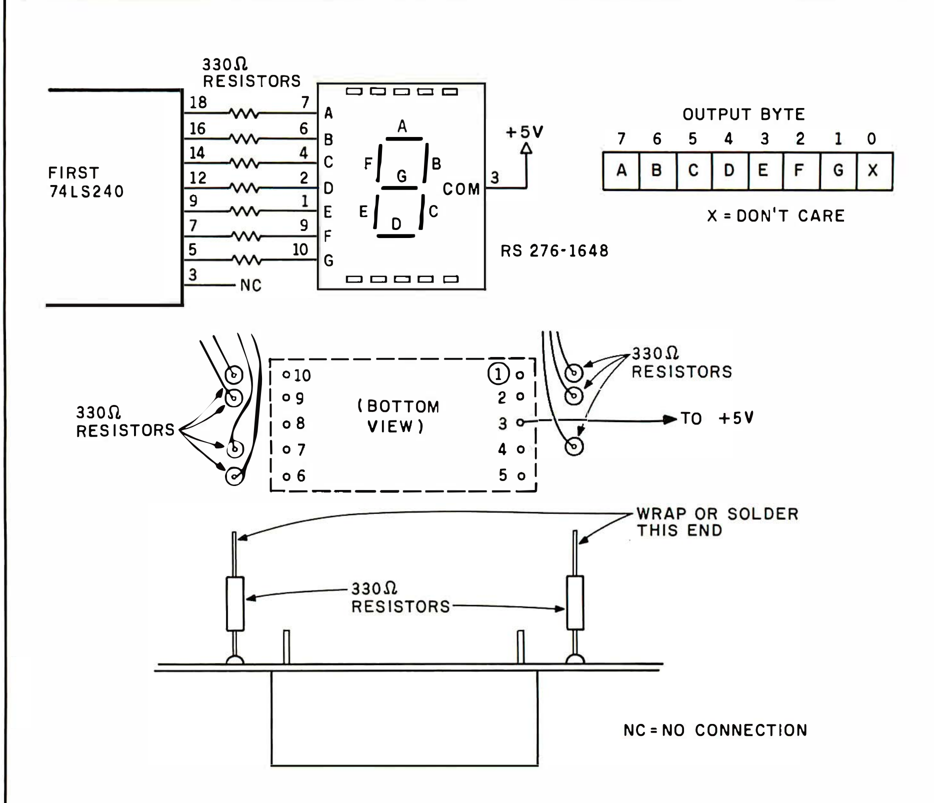


Figure 12: *Sample LED driver application for the GPIO. The seven segments of the LED display are driven by seven output lines from the 74LS240. LED segments turn on when the lines are at 0 volts.*

Listing 2: *Demonstration program for the LED driver.*

```
90 ' DEMO MODEL I PROGRAM FOR 7-SEGMENT LED OUTPUT
100 OUT 3,137
105 INPUT V
110 OUT 0,0
120 GOSUB 1000
130 OUT 0,V
140 GOSUB 1000
150 IF INKEY$="" THEN GOTO 110 ELSE GOTO 105
1000 FOR I=0 TO 1000
1010 NEXT I
1020 RETURN
```

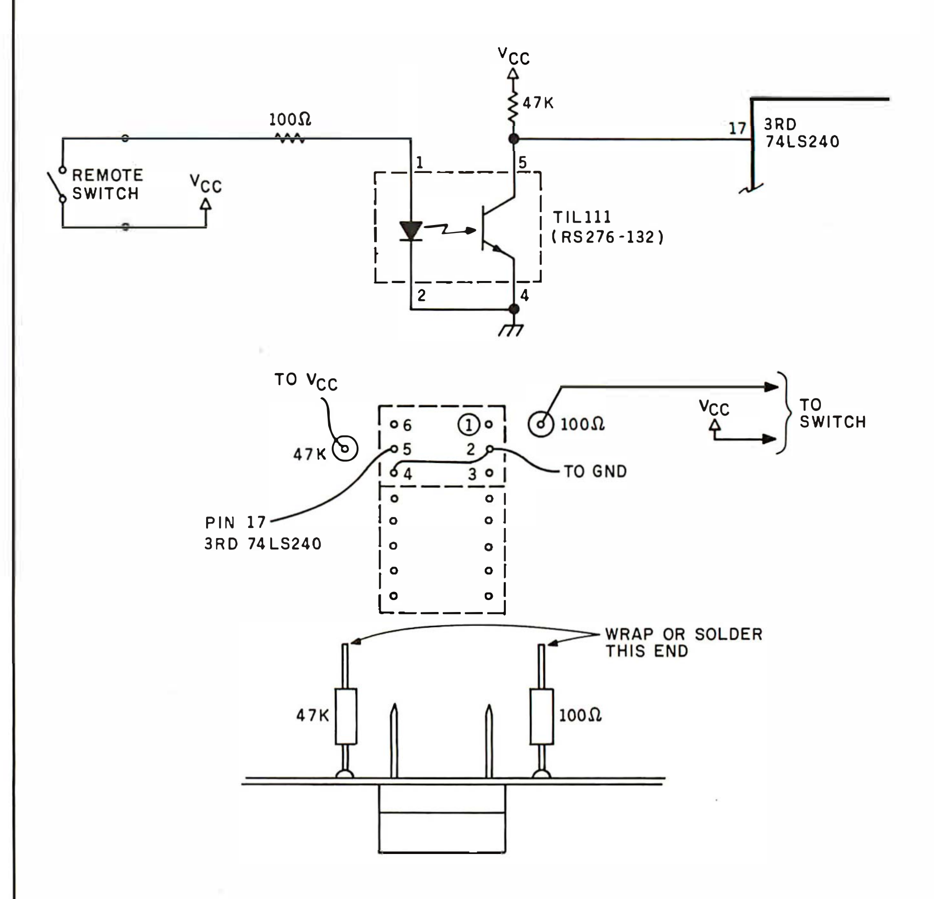


Figure 13: *Sample optoisolator application for the GPIO. A remote switch lights the LED contained within the optoisolator. This turns on the phototransistor, bringing the collector to a 0 level.*

276-1648, but any similar *common-anode* display may be used.

Wire the display as shown in figure 12. The 330-ohm resistors may be stood on end and wire-wrapped on the free end. The current-limiting resistors are connected to the first 74LS240 as shown in the figure.

The Model I BASIC program shown in listing 2 will drive the LED display and illuminate any combination of the seven segments. Insert a "95 OUT 246,16" for the Model III version.

A second application is a remote sensor. Although I've used just one input, up to eight could be used in the GPIO configuration I'm using. The

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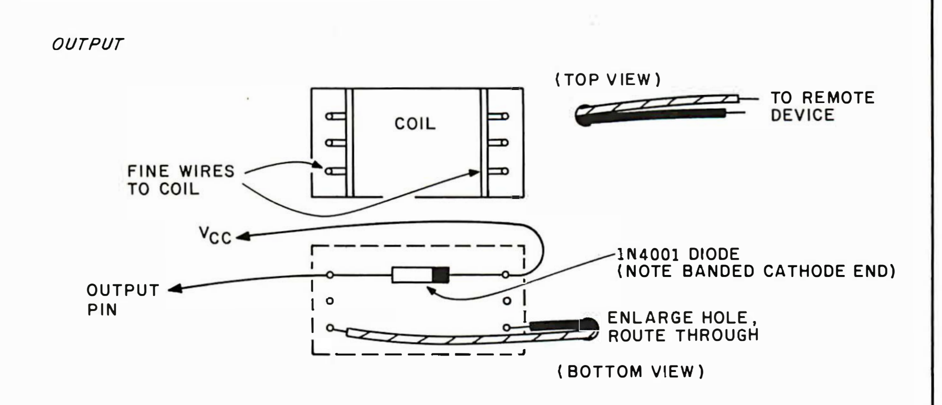
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CP-202C

Listing 3: *Demonstration program for optoisolator input.*

```
100 'DEMO MODEL I PROGRAM FOR OPTO ISOLATOR INPUT
110 OUT 3,137
120 PRINT INP(2)
130 GOTO 120
```



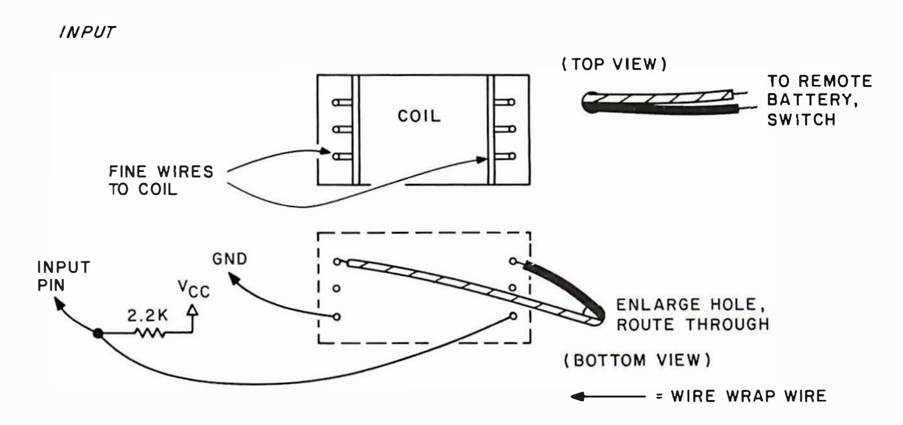


Figure 14: *Physical layout of the Radio Shack DIP (dual-inline package) relays. The relays may be used for both input and output.*

remote sensor uses a Radio Shack optoisolator IC. The optoisolator contains an infared LED and phototransistor in one package, as shown in figure 13. Remote-switch closure lights the LED and causes the transistor to conduct, bringing the input line to pin 17 of the 74LS240 down to 0.

The optoisolator is a "current-driven" device, allowing the connecting line to be any length as long as the current is sufficient to light the LED and cause the phototransistor to saturate. The optoisolator eliminates the noise problem associated with TTL (transistor-transistor logic) inputs.

The wiring diagram for the remote sensor is shown in figure 13. Again, the resistors may be positioned on end. Use the program shown in listing 3 (Model I) or listing 1 (Model III) to test the optoisolator action.

A third application uses relay input or output. The physical layout for both input and output is shown in figure 14. Radio Shack 275 through 228 relays (22.5 mA) are used and may be mounted on the board as shown. These relays will handle up to 0.75 ampere (A) on their contacts and can be used to drive a load larger than the 10 or 40 mA output of the 74LS240. ■

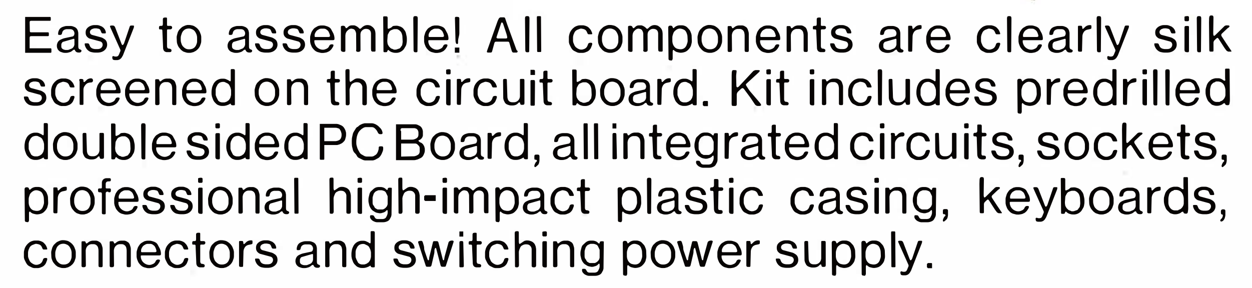
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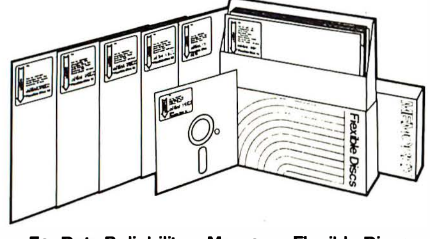
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The Logo Journal

News and Views of the Logo Community

Learning Physics from a Dynaturtle

Andrea A. diSessa and Barbara Y. White
The Division for Study
and Research in Education
Massachusetts Institute of Technology
Cambridge, MA 02139

The Logo turtle has proved a remarkably good microworld in which students can experience and learn mathematics painlessly while pursuing personally satisfying activities. To see if a similar idea could work for physics, author diSessa created a dynamic turtle, *dynaturtle* for short, which obeys Newton's Laws of motion. A dynaturtle remains at rest or travels at a uniform velocity in a straight line except when acted on by forces. The forces are little pushes, or kicks, specified by the student via the keyboard. Depending upon their direction, kicks can cause the dynaturtle to speed up, slow down, or change direction. (Although a dynaturtle doesn't presently come built in to Logo, the language makes it extremely easy to add one.)

Experience with elementary school students proved that even simple activities with the dynaturtle (such as driving it to intercept a target) were, indeed, both motivating and instructive. For example, the students had an apparently deep-seated misconception that things always go in the direction you push them. In reality, as Newton showed and a dynaturtle exemplifies, a push merely adds to the existing momentum of an object and typically only deflects it.

When the students translated this belief about force and motion into a strategy for hitting the target, as shown in figure 1, they would inevitably miss the target. With time and practice, the feedback from the microworld allowed the students to gain a better understanding of how forces should affect the motion of an object. Subsequent work with university physics students showed misconceptions and patterns of learning similar to those held by the elementary school students. This accords with recent research that shows how little conventional instruction affects intuitive beliefs concerning the laws of physics.

Figure 1: *Dynaturtle helps students gain a better understanding of how force affects a moving object.*

Dynaturtle, like the original Logo turtle, is a tool for students and teachers alike. Various researchers have and are creating materials for using a dynaturtle in the context of a programming experience for elementary school students (including handicapped students, as a replacement for the usual kinesthetic experiences through which we develop physical intuition).

To aid in teaching physics, author White has developed a "curriculum" in the form of a series of games using the dynaturtle. The idea is that with particular goals and problem situations, the games will focus students' attention on difficulties in their conceptions about force and motion and thus, step by step, lead them to a solid understanding of the problem.

White's curriculum began with a detailed study of the many kinds of difficulties high school students have with fundamental force and motion problems. She concentrated on the simplest qualitative ideas where "formula cranking" will not help. Thereafter, she developed the series of games and also devised a set of problems to assess changes in the students' level of understanding. In a controlled experiment, the games proved strikingly successful at eliminating basic misconceptions and at improving overall understanding. This finding is an encouraging indication that such game-like activities can be used not only for entertainment, but also for solving significant pedagogical problems. ■

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Logo Music

Jeanne Bamberger
The Division for Study
and Research in Education
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Logo music has been quietly evolving over the past 10 years within the larger Logo environment. Logo music was first implemented on the PDP-10 with the help of Terry Winograd, using a digital music-box peripheral designed by Marvin Minsky. The present version of Logo music, completed last year, was built by Leigh Klotz and Hal Abelson as a special version of Logo for the Apple II.

Logo music uses an ALF synthesizer board for sound generation connected to a simple stereo amplifier and two speakers. With the full capabilities of Logo itself (except for graphics), together with the ALF board, there are six operative voices, a six-octave range, eight parameters available for user manipulation of the sound envelope, two percussion sounds, and almost immediate response time between typed commands and resulting sound. Altogether this makes quite a powerful system for interactive, composition-like projects.

In the spirit of Logo, the music language has been designed to be as intuitive as possible while at the same time lending itself to serious, almost endlessly expanding musical projects. The system is sufficiently flexible and powerful to be appropriate for beginning or more advanced music students of any age. It can be used as "scratch paper" for musically sophisticated composers who wish to experiment with musical design through procedural descriptions.

The system is also useful as an additional medium (along with turtle geometry, for instance) within which to develop procedural thinking, problem-solving skills, new applications for general arithmetic functions, and concepts concerning speed and distance relations.

Logo music contrasts with other educational computer-music programs in two fundamental ways: (1) based on our ongoing research into musical cognition, we have tried to develop an environment that builds on students' intuitive musical knowledge rather than simply computerizing traditional music instruction, and (2) we have tried to exploit the potential of the computer for truly interactive, real-time experimenting.

For example, we have made it easy for students to design higher-level procedural descriptions of musical relations. For example, the notion of meter is not taken as given but as something to be generated procedurally by the students themselves. The structure of the major scale (or, indeed, tonality) need not be simply taken for granted but rather can be *constructed* as a procedure that chooses from the complete pitch col-

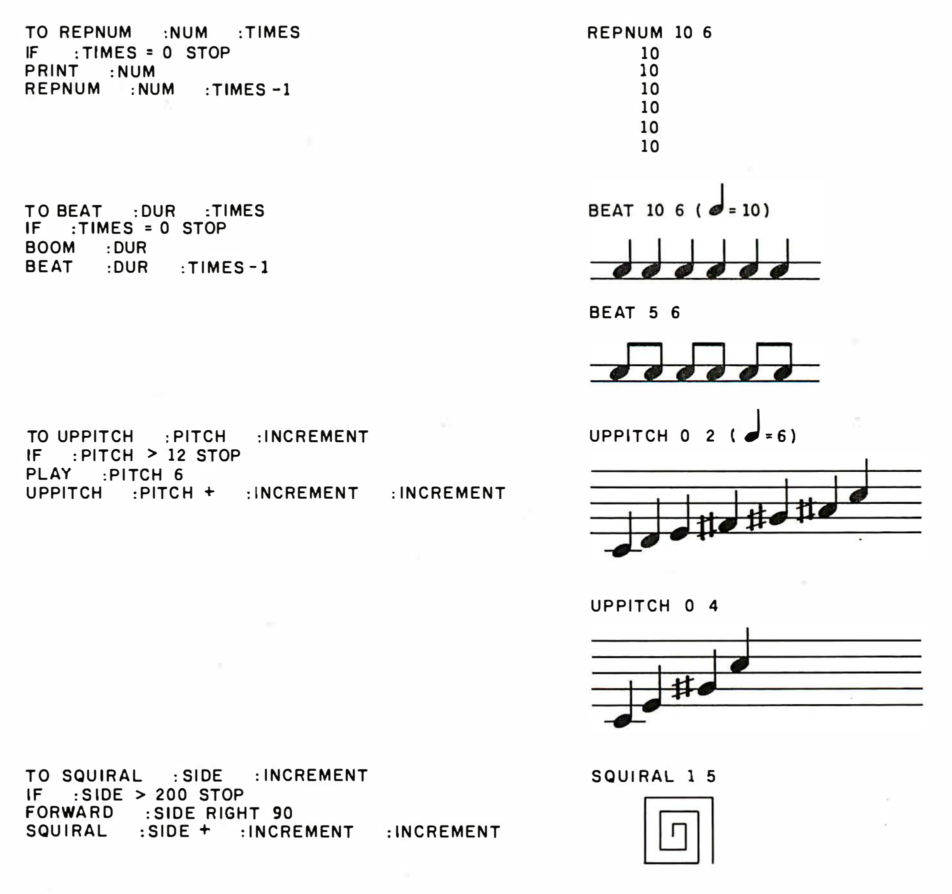


Figure 1: *Four Logo procedures with the same structure produce different effects.*

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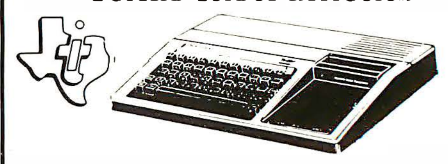
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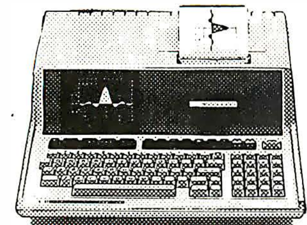
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lection as a special case but one that can be generalized. Further, we have taken multiple descriptions to be a central tool in creative learning. Thus students work at different levels of musical structure and with varying units of description. Tunes can be built using whole, preprogrammed figures, and melodies can be transformed and regrouped by manipulating pitch only (with rhythm given) or rhythm only (with pitch given). Or coherent structures can be designed using procedural relations as the operative entities—sequence, intervalic relations, texture, and harmony. Procedural design becomes, then, a kind of model for developing musical thinking, for the development of active, informed listening to real music, and the basis for building musical structure itself.

In this process new modes of description and new musical insights emerge. Consider, for example, what happens when Logo musical experiments are juxtaposed with Logo experiments in other media.

In the examples of figure 1 we see the *same* procedure producing quite *different* effects as a result of the actors they are talking to: PRINT, BOOM, PLAY, FORWARD (TURTLE). The procedures, then, including the notion of recursion, can be seen as organized actions of a particular sort. Their meanings as *apprehended* are, on one hand, entirely different, but on the other can be seen to share common underlying, dynamic structures. Experiments of this sort can help students to gain new insights into familiar phenomena, to expand their understanding of these phenomena, and to develop powerful tools that can serve as "things to think with."■

Leading Fish to Water
Early Observations on the Use of Logo

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Since August 1981, the Faculty of Education at Queen's University has, through the kind permission of Professor Harold Abelson, been a test site for the MIT version of Logo for the Apple computer. For six months, using a prototype of the system now distributed commercially by Terrapin and Krell, a small group of faculty members, graduate students, local teachers, and interested members of the community has spent time using the Logo facilities of the Instructional Computing Laboratory, which has five Apple II Plus computers.

The Logo learners varied in age from 6 up (several people worked with their own children) and the class size ranged from 1 to 15. Although no systematic study was carried out (our first intention was to familiarize ourselves with the system), there appears to be a consensus on a number of issues. Perhaps the two most important have to do with the potential of Logo and the likelihood of this potential being realized in schools. Briefly stated, our enthusiasm for the language started out high and has continued to grow, but we are not optimistic about the chances of an authentic version of Logo reaching the average classroom.

We cannot fail to be impressed by the quality of the work done by Seymour Papert and his colleagues. The claims made in *Mindstorms,* for example, are ambitious and ones about which a cautious observer would tend to be skeptical. Our feeling, however, at least at this early stage in our work, is that these claims are substantially sound.

Logo appears to touch something quite fundamental in children's learning procedures irrespective of the "school ability" of the child. The speed at which the group of self-confident 10-year-olds in my afternoon enrichment class grasps ideas is, however, particularly impressive. Negative numbers and Cartesian coordinates, for instance, get gobbled up in a two-minute discussion of SETXY. The unforced way in which powerful ideas emerge from the turtle geometry microworld is in stark contrast to the struggles of traditional teaching. The old riposte "you can lead a horse to Euclid but you can't make him think" did not seem to apply. The naturalness of the children's responses to questions that emerged from Logo situations made me feel that I was bringing not horses (or cats) to this educational pond, but fish.

It seems, then, that Logo is not just the best educational software on the market at the moment (not, in itself particularly high praise), but a new type of educational resource with enormous potential for developing

About the Author
Dr. Higginson is also editor of Logophile, *the newsletter of the Logo Special Interest Group of the Educational Computing Organization of Ontario.*

the social, aesthetic, emotional, and intellectual abilities of learners. I wish that the availability of such a powerful tool would, by itself, imply an improvement in the quality of education of the average child. Unfortunately, a realistic assessment of the situation indicates that such a result is not very likely. One basic problem lies in the absence of what is known in the Third-World context as "secondary infrastructure." At the first or developmental level, excellent work has been done, and at the third or field level, there is a great need for a resource such as Logo. Yet between these two levels, where a substantial group of well-trained and experienced consultants and teacher educators is essential, there is an almost total void. It will be the rare classroom teacher who will be able to get assistance from anyone who has had any degree of experience with the use of Logo. Resource materials such as Abelson and diSessa's excellent *Turtle Geometry* are simply out of reach of most teachers without regular and sustained assistance. It seems unlikely that this assistance is going to be available to more than a small percentage of teachers.

A second and probably greater barrier to the implementation of an authentic version of Logo in schools is the nature of the underlying philosophy of the language. Logo is child-centered and, at least on the surface, unstructured and nonhierarchical. Many teachers at present feel pressured to have formal, hierarchical and content-centered curricula. There is, however, much more structure to Logo than meets the eye; students are free to roam wherever they choose *within* the boundaries established by the rich and highly structured Logo environment.

Logo no doubt will be used, but the form of Logo that will evolve in many cases will have little in common with Papert's original vision. Just as educational psychologists in North America ignored the inherent contradictions between neobehaviorism and the child-development theories of Piaget, curriculum writers will see no difficulties in the creation of turtle geometry workbooks to teach basic mathematics in a highly formalized way.

At another level, however, the "degree of guidance" problem is difficult to cope with. The questions of what sort of assistance is best for which children under what circumstances are not likely to find any quick or widely agreed upon answer. Nor will any of the widespread problems that face classroom teachers automatically disappear with the introduction of Logo. In the long run, languages like Logo may prove to be a help with children who are emotionally disturbed or educationally handicapped, but that remains to be seen.

To say these things is not to disagree with Papert. For teachers who feel comfortable with mathematical ideas like recursion and symmetry and who have some freedom of choice in curriculum matters, Logo is likely to be, at least in the short run, a powerful educational tool. (The value of long-term use of Logo is a more open question. I am aware of no extended studies of children using Logo.) For the other group of teachers a great deal of work must be done before they can realistically be expected to use the power of this most attractive language. ■

Logo Project PROKOP

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The Logo research project in Darmstadt, West Germany, started in 1974 and ended in late 1979. It was a large project conducted by an interdisciplinary group of up to seven researchers and supported by the federal government.

Work started after an evaluation study of computer uses in schools which concluded that the most promising way to use computers was not CAI (computer-aided instruction) but to give the computer to the student as a tool.

Empirical work was considered important right from the beginning and the project installed several terminals connected to a DEC PDP-10 at a local high school (later on, personal Logo machines from General Turtle were added). Of the different approaches tried in the project, only the work done by the two authors will be surveyed in the following description. Other approaches involved different kinds of experimental classes and students of different ages.

We worked with high school students from 15 to 18 years old. Our main concern was to teach problem solving in the context of an interesting environment. We taught several experimental classes over periods

ranging from 18 months to 2 years. We considered the long duration important so the students would have time to get beyond the stage of solving trivial problems or fighting with the technical problems of the system.

We used Logo quite differently compared to other Logo projects. Although turtle geometry was one of our projects, our main concern was using Logo as a full list-processing language that makes possible projects of nontrivial complexity. Seen from this perspective, Logo is a version of LISP that is oriented toward the nonexpert user.

We have developed extensive curriculum material that we tested with the students and have carefully documented (including a very detailed documentation of the programs) in five volumes covering nonnumerical mathematics, linguistics, computer science, artificial intelligence, and games. The publications are in German and can be ordered at the following address: Hessisches Institut fuer Bildungsplanung and Schulentwicklung, Bodenstedstrasse 7, D-6200 Wiesbaden, West Germany.

The theory of our work was based not only on Piaget's research but also on problem-solving work from Polya and Newell and Simon. We made some efforts to teach cognitive abilities (e.g., planning, abstraction, generalization, and understanding) by doing projects in the above areas.

We made a big effort to integrate our work with the students' other activities and interests. It seems to us that many Logo projects failed to achieve this integration. We felt we had to build bridges between the innovative strategies of the Logo work and the other interests of students and teachers. One of our goals was to create a place for this work in German schools, and we were in favor of establishing a new discipline of computer science (not just an imitation of the university subject) in German high schools.

We tried to use the existing expertise in German schools, which was in BASIC programming, and showed how to practice a functional, procedure-oriented style of programming with some versions of BASIC.

Our more theoretical work included among other things the development of a theory for the construction of learning environments through the creation of entry points, transient objects, and microworlds.

The last two topics are described in two English papers by the authors published in the proceedings of the International Federation for Information Processing world conference on "Computers and Education," Lausanne, 1981. These two papers also give references to our other related work. ■

The Group of the Turtle

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When observing children working with the Logo language, it is obvious that a lot of group theory goes on. This project investigates the place of group theory in Logo work from three points of view: mathematical, computational, and educational. [**Editor's Note:** *Group theory is a branch of mathematics that deals with the study of mathematical groups. In common terms, a mathematical group is a collection of objects (such as members) and operations (such as addition) such that the result of every operation is another object in the group. The set of actions carried out by the Logo turtle form a mathematical group, called "the group of the turtle" in this article. The article refers to a set of studies of the ways that children who learn Logo learn about the properties of mathematical groups.*]

Mathematically, myself and my colleagues want to make explicit the group-theory concepts and structures that are implicit in Logo. This forms a bridge between Logo and standard mathematics and prepares the ground for the later stages. The basic object here is the *turtle group*, generated by the turtle operations FORWARD, BACK, RIGHT, and LEFT with all possible inputs. (Adjoining the PEN and ERASER commands to the group raises interesting issues.) Here are, in brief, some more group-theory concepts that we have observed in the children's work (accompanied by their Logo counterparts):

- products and decompositions (paths traced by the turtle)
- inverses (opposite operation)
- the order of a group element (the number of repetitions to close a path)
- conjugacy (transparent operations and procedures)
- subgroups (limiting oneself to only a special subset of allowable inputs)

- free groups (this is where the Logo *procedures* live)
- homomorphism (the relation between Logo procedures and their products)

For example, the fact that the path drawn by REPEAT 5 [FORWARD 50 RIGHT 144] closes is reflected in the group by the relation $(F_{50} \times R_{144})^5 = I$ (the identity element); that is, by the fact that the group element $F_{50} \times R_{144}$ has order 5.

Computationally, we try to bring these concepts to the fore by implementing a special-purpose set of primitives to encourage explorations in the turtle group. This is related to Seymour Papert's notion of microworlds. For example, the procedure FIND.ORDER takes a list of turtle commands as input, repeats this list until the path closes, and outputs the number of repetitions.

Educationally, we plan to observe children of various ages (as well as adults) working with a group-theory-speaking turtle and see to what extent informal learning of these concepts does occur.

This work may be extended in many ways. Here are two. First, different turtles give rise to different turtle groups (see diSessa's dynaturtles, in Papert's *Mindstorms* and see page 324 in this issue), and it is interesting to explore the collection of groups that can be naturally represented as turtle groups for some turtles. Second, the method of implementing a special-purpose vocabulary may be applicable in many areas. This is probably the Logo analog of the notion of courseware development in more standard computer applications. It helps direct the explorations of the children working in Logo to specific subject-matter areas, without sacrificing the spirit of spontaneous and meaningful learning. ■

The Lamplighter Project

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Typically, when researchers wish to determine the effectiveness of an educational method, they design a program, randomly assign students to either that program or a control group, administer a test instrument specifically designed to measure performance from the program, and then express surprise that the students in the control group do not perform as well as the students in the special program.

Many advocates of the use of computers in education have been among the most flagrant with such techniques. The research literature overflows with such studies where, for example, after six months of intensive drill on addition, students' addition skills improve. Perhaps such teaching to specific test questions has an appropriate place in education, but it is much more important that students learn how to think, how to solve problems, and how to learn. One of the objectives of the Lamplighter project was to determine if Logo could be used by students to learn better thinking, problem-solving, and learning skills.

It is, of course, a simple matter to assess addition skills. By comparison, it is quite complicated to measure thinking, problem-solving, or learning skills. No one test and no single study can do more than begin to explore these skills and changes in them that result when children use Logo.

I used a test called rule learning, taken from cognitive psychology. In rule learning, students are shown a series of pictures, usually with one of several shapes shaded in one of several colors, with the size of the shapes shown either small, medium, or large (comparatively) and with either one, two, or three exact replicas of the shape present. For example, a picture might show three small, red triangles or one large, blue circle. In rule learning, students are told which features to pay attention to, e.g., a problem might have red and circle as relevant features, and students would be told to pay attention to them. Students are then required to learn what combination of those relevant features satisfies the binary rule chosen by the experimenter. For red and circle relevant, the possible rules are conjunction (only pictures of red circles obey the rule), disjunction (pictures of any red shape and of any circle obey the rule), conditional (pictures of red circles and of all nonred shapes fit the rule "if red, then circle; if not red, then any shape"), and biconditional (pictures of red circles and of nonred, noncircular shapes fit the rule "if red, then circle; if not red, then not circle").

To solve a rule-learning task, students have to be able to symbolically manipulate the features, ignore irrelevant features, process information from current pictures, and combine that information with their memories from previous pictures. For third

graders, the conjunctive and disjunctive rules are fairly simple because the students experience forms of these rules in their everyday lives. The conditional rule is much more difficult for them, and the biconditional is harder still.

Students in the Lamplighter School third grade were randomly assigned to one of three homerooms which had two Texas Instruments computers. Five more computers were located in the shared space between the three rooms. After homeroom, students went on to classes with each of the third-grade teachers. Two of the third-grade homeroom teachers elected to ensure that each pupil received one half hour of Logo a week and the other teacher set a one-hour-a-week minimum for her students. This difference existed from the start of the school year through the last week in April when students from all three classes were given the task of learning the conditional rule. The students from the one-hour Logo homeroom performed significantly better than the other two groups and better than even a sixth-grade level.

What is most important about these results is that the children were not taught to the test. Rather their extra Logo sessions improved a more general problem-solving skill. It would be premature to take this one study as conclusive evidence that Logo improves all thinking. The results should be taken to encourage similar studies with other measures of thinking and other groups of people. ■

Logo Research at Bank Street College

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Microcomputers are being used in many schools throughout the United States in the belief that they have important educational potential for children. However, little research indicates what children learn from working with microcomputers, how they learn to work with the technology, and in what ways such skills relate to other academically relevant skills. We are particularly interested in the educational possibilities for children who learn to program microcomputers with Logo. Among the organizations funding the Center's research are the Spencer Foundation, the Xerox Foundation, and the International Paper Company Foundation.

Our research is concerned with revealing how children acquire computer programming skills and how the use of microcomputers in classrooms may relate to other cognitive and social skills. Research supported by the Spencer Foundation is being conducted in two classrooms (one of 8- and 9-year-olds and another of 11- and 12-year-olds) of the Children's School at Bank Street College of Education. The children are learning to program with Logo, and in each classroom they have access to six microcomputers. They can work alone or together as active programmers of their own projects.

We are investigating a number of specific questions concerning

children's experience with Logo. One set of studies addresses the relationship between computer programming and problem-solving skills. It has been widely assumed that computer programming experience will enhance problem-solving abilities (Papert, 1980) because of the modular character of the work and the necessity of using debugging processes. However, this assumption has never been systematically tested. Therefore, one aim of our research is to examine relationships between the degree of Logo programming expertise and problem-solving and planning skills through longitudinal studies. This will enable us to determine the impact of Logo programming skill development.

As part of this investigation of the development of children's programming abilities, we will document the growth of knowledge about Logo as a language as well as knowledge of computers. Our work on Logo programming expertise will center on case studies of changes in children's knowledge of Logo over time in relation to the use of their knowledge to achieve project goals.

We are also investigating the social context of microcomputer use in classrooms. It has been observed in several different educational contexts that children seem to collaborate and teach each other more when they work with microcomputers. One study which we have completed indicates that children talk more to each other about problems they are doing when they work with the microcomputers, as opposed to other classroom work. Both the occurrence and quality of the interaction when children work together are of interest to us because we believe collaborative work to be an important learning context.

In addition, we are documenting the process by which the teachers incorporate microcomputers and the use of Logo into their classrooms. This work will be useful for addressing key questions concerning the best ways of using microcomputers with children in school. The research is intended to clarify our basic understanding of planning, problem solving, and peer interaction in classrooms for this relatively new domain.■

Young People's Logo Association

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And this is the way to educate children: the instinctive way of mothers. There should be no effort to teach children to think, to have ideas. Only to lift them and urge them into dynamic activity. The voice of dynamic sound, not the words of understanding. Damn understanding. Gestures and touch, and expression of face, not theory. Never have ideas about children—and never have ideas FOR them.

—Fantasia of the Unconscious and Psychoanalysis and the Unconscious
D. H. Lawrence

This quote from D. H. Lawrence is what the Young People's Logo Association is all about. But at the time of our founding, in summer 1981, no one was thinking about Lawrence's statement. We thought we could just buy a few TI-99/4 Logo systems and let my son, Larry, and his friends enjoy having a young people's users' group and software exchange. We soon started writing a newsletter.

We also wanted disabled individuals to enjoy the fruits of the computer revolution. We were dismayed to find so little information available on computer applications for the disabled but pleased to learn of the experimental success in this field with Logo.

We soon developed into a small group of teachers, media specialists, and journalists who wanted young people and the disabled to participate fully in the world of computers. We have come to believe that Logo and turtle graphics can open this world to both groups.

At first we thought we would be corresponding with children who were already using Logo in their classes. We were surprised when our publicity generated interest from all over the world and from people using all types of computers. When I brought home an Atari 800 system, we had another surprise. The young people immediately began to ask whether Logo could run on the Atari, and whether the Atari graphics could be duplicated in Logo. We then began to look at the differences between the Atari 800 and the TI-99/4. From that point, the imagination, curiosity, and energy of the young people took over and became infectious.

Logo and the Young

When people learned about the international membership of the association, they wanted to see chapters

formed in schools around the United States and around the world. As our group grew, members wanted to learn about all kinds of computers and languages. A reporter asked why we called our organization a Logo association when it was obvious that we were doing much more. But nothing can be "much more" than Logo. A well-structured, procedural language, Logo lets young people start with what they know—their own everyday language. Logo lets you define a problem in its simplest components and then reassemble the components in a procedure for solving the problem with a computer. Using turtle graphics, people learn to "play" the computer, creating their own language through Logo. In the process, they not only gain valuable experience in problem solving and decision making, but also develop confidence and self-esteem.

Young people see the computer for what it is—a tool of the mind. Just as they don't blame the pencil for a mistake in writing, they don't blame the computer for a mistake in programming. Indeed, young people don't view their errors as mistakes but as bugs to be defined and eliminated.

Logo introduces problems to children in a way that makes them eager to learn. Children are, in Lawrence's words, lifted and urged into dynamic activity. You can see the dynamic power of Logo in the eyes of a 6-year-old as he sees *his* procedures run correctly for the first time. You can see the power in the concentration of a hyperactive child still working over the keyboard after an hour of programming.

Logo and the Disabled

Logo can be equally powerful in the service of the physically and mentally handicapped. Personal computing is a whole new world for these people, and Logo can help them build confidence, self-reliance, and dignity. Logo creates opportunities for education, communication, productive employment, and significant contributions to society. Logo provides outlets for creativity and imagination.

The YPLA has members throughout the United States and in many other countries. Young people 18 and under can receive our newsletter, *Turtle News,* at no charge. We ask adults in North America to contribute $25 per year to receive *Turtle News* plus the *Logo Newsletter,* which is oriented toward adults. The requested contribution for international membership is $40. Our software exchange disks and tapes are available at $10 each or at no charge when exchanged for a working program.

We have active local chapters in Texas and others on the way in California, Minnesota, Delaware, Pennsylvania, Florida, Virginia, and elsewhere. Local chapters will offer competitions, achievement levels, badges, T-shirts, and all the other elements necessary to give children a sense of belonging to an organization of their own.■

Logo Update

Phil Lemmons
Consulting Editor

This report provides recent news from Logo projects and classes around the United States and Canada. Far from assessing the status of Logo in American and Canadian education, the report merely hopes to capture something of the character and spirit of the people who are teaching Logo or guiding Logo projects. Logo projects and programs exist from coast to coast: from the Microcomputer Resource Center at

Teachers College at Columbia University in New York, to the Marin Computer Center in Corte Madera, California. Telephone calls to participants in many Logo activities invariably found people enthusiastic about Logo and its future. It was seldom necessary to ask questions after saying something like, "Tell me what you're doing with Logo." Explanations and anecdotes came pouring out. What follows is only a sampling.

East Aurora High School
Erie County, New York

Dan Rolfler teaches in the mathematics department at East Aurora High School. Last February and March, the school offered an enrichment program called "EastOz." This program provided learning experiences for children on six Saturday mornings.

Texas Instruments lent the school six TI-99/4 computers. Forty students took part. Separate classes were held for grades 2-5 and 6-8. Children were taught problem solving and organized thinking. "You see different children solve the same problem in different ways," Rolfler says. "It's exciting to watch the kids. Logo is the best means I've seen for discovery-method learning."

While the younger children needed more class time, the children from fourth grade up "took off on their own," Rolfler reports. "What Papert suggested really does happen." Rolfler also noted the tremendous educational potential of Logo in the home.

Besides the program for students, East Aurora High School has a computer-literacy course for teachers that introduces them to both Logo and BASIC. Furthermore, the Erie County Board of Cooperative Educational Services is considering using Logo in curriculum development work.

Eastside Alternative School
Eugene, Oregon

Tim Riordan teaches Logo at the Eastside Alternative School and expresses few reservations about the language. "It's real fantastic in terms of developing analytical thinking and problem-solving skills," he says. "The graphics approach appeals to kids' interests, both girls' and boys'." Riordan also commented, "There's no limit. Kids as young as third grade can work with the idea of variables and can use recursion and develop things that are ongoing."

Riordan offered an example of the kind of abstract thought developed by children using Logo. When a math teacher described a circle as having no sides, a 10-year-old student in a Logo class remarked that a circle could be thought of as an infinity of very small sides. Logo had enabled that child to internalize the concept of the infinitesimal, so important later in calculus.

Riordan is also optimistic about Logo's surviving any imposition of curriculum standards. "I see no reason," he says, "why you couldn't put all of junior high geometry in Logo classes."

The Eastside Alternative Logo effort teaches 75 children from first to sixth grade. There is one 45-minute Logo period every day for three weeks. Some parents have taken the Logo class with their children.

Hamilton-Wenham School District
Hamilton, Massachusetts

Pat Ruane, curriculum coordinator for the Hamilton-Wenham School District in Hamilton, Massachusetts, reports that the district has been experimenting with Logo for one year. As a result, it has decided to focus its Logo program beginning in the third grade in three different schools. Classes for sixth graders, junior high students, and a formal Logo programming course for adults have been set up.

One of the third-grade programs has three Apples circulating among three classrooms. The machines are in use all day, and every child has lots of time with a machine. For children in the program, using computers has already become second nature.

Some of the children first developed an interest in computers in first and second grade while using the school's Big Traks—robot-like, programmable toy vehicles. Programming more than one Big Trak, coordinating the movements in what the school calls "Big Trak Ballet," required children to plan carefully. Highlights of Big Trak Ballet include programming vehicles to mirror each other's movements or to arrive simultaneously at the same place after leaving different origins at different distances.

As for the Logo program itself, Ruane sees students receiving more benefits than just an early introduction to programming. Because they share machines, the children gain important social experience. They are grouped heterogeneously and their interaction leads to increased mutual respect.

Children also learn general thinking skills, especially how to analyze problems. Third-grade teachers say that the children who excel with Logo are not necessarily those who do well on traditional mathematics tests. This suggests that traditional measures of ability in mathematics overemphasize computation.

Logo also provides benefits for teachers. According to Ruane, there is "a different relationship between teacher and learner. Teachers ask, 'Can I still engage as a learner?' This changes teachers' views of teaching. Logo has opened up the whole question of how mathematics should be taught."

As for other educational software now on the market, Ruane says, "I would as soon throw out all our other software and just use Logo."

Falk School
Pittsburgh University
Pittsburgh, Pennsylvania

Sharon Lesgold is curriculum developer for a Logo demonstration class in the Falk School, a laboratory school at Pittsburgh University. The program has 49 children aged 5 to 8 using Terrapin Logo for the Apple.

The Logo Journal

The children, some from the Pittsburgh urban area and some the children of faculty, share a total of three machines in a connected suite of several large rooms.

Lesgold describes the Pittsburgh program as "very developmental. Not much real programming yet. The children are mostly drawing pictures." Each child has use of a computer for 30 minutes a week.

Lesgold has altered the Logo commands somewhat, notably making turtle steps 10 times as big as usual. Also, instead of describing a movement in degrees, the children use directional terms—north for the top of the screen, south for the bottom, etc. The children find these terms easier to use, partly because the directional references in the Logo course are consistent with the children's parallel introduction to map skills. Lesgold comments, "The kids understand the power of Logo and how to use it."

A summer day camp is planned for children from first to sixth grade, with the majority in the fourth and fifth grades. The camp will offer 4 computers for a class of 20 children, with 1 teacher and 1 aide. Lesgold hopes that the increased computer time will make it possible for children to learn to write procedures. The summer instruction will be more structured than that given during the school year. Children will have more definite tasks to do.

The Young People's Logo Association Richardson, Texas

Jim Muller of the YPLA reports that the group is developing a version of Apple Logo that incorporates a single-keystroke language for the physically disabled. (See page 333 for a report by Muller on YPLA.) The enhanced Logo will present a menu of words and phrases and convenient means to construct sentences from them and print the results. Toggle switches and gravity switches will replace standard keys and make using the computer easier.

Jack Kishpaugh, who finished near the top in the Johns Hopkins competition for computer applications for the handicapped, is using Logo to develop a utility disk for the severely disabled. Kishpaugh, himself disabled, is trying to reduce the number of keystrokes required for successful communication from the usual range of 200-300 to only 20-25.

The YPLA is also beginning to investigate the use of voice input and is seeking ways to interface voice-recognition systems with the Logo language.

As for instruction in Logo, the YPLA tries to help elementary school children learn fundamental programming concepts like interrelationships among blocks of data. Muller notes that "Logo also helps children develop good social relationships." At least two children work on each project, and as a result, children get a greater sense of accomplishment on completing a project.

Muller expects tremendous growth in the exploitation of Logo's powerful list-processing capabilities. The most obvious application is in the language arts. Logo's features make it relatively easy to develop word games and language exercises. He also believes that the use of Logo will expand in many other directions.

Austin College
Sherman, Texas

Dr. Henry Gorman, whose report on the Lamplighter Project appears on page 331 of this issue, uses Logo in his Principles of Learning class at Austin College. The class has four TI-99/4s that are used most of the day for Logo. Each of the 40 college psychology students uses Logo in working with 1 student between the ages of 7 and 14. Thirty-nine of the college students were enthusiastic about Logo.

Celeste Alexander, one of Dr. Gorman's college psychology students, describes her experience with a young Logo pupil this way: "After the first day we worked nearly exclusively with sprites. He liked everything to be put into a program." Of her own reaction to Logo and to learning to use a computer, Alexander says, "I found my first apprehensions dissolved and I realized I could not only run or manage this computer, but also understand what I was doing."

Janet Truska, another of Dr. Gorman's students, also had good results to report. "I was concerned as to whether my student would enjoy it or not," she says. "After we worked with it a while, he began to enjoy it, as did I, and we both found it to be a very rewarding learning experience."

This summer, Austin College is offering a continuing education course in Logo. Students range from the second grade to the twelfth, divided into

four classes with a three-year age span. The college may offer a Logo course for parents at night this fall.

Ponderosa Elementary School Cherry Creek School District Aurora, Colorado

Jim Wilborn, who is active in the Logo program at Ponderosa Elementary School, says that the school is now using seven TI-99/4s with Logo. Since October 1981, pairs of children have had access to TI-99/4s, with each session lasting 15 minutes. The students show enthusiasm for Logo, battling for additional time at the Logo keyboard, but also sharing ideas. The students are developing improved skills in general problem solving, logical-sequential organization, and spelling. Many of the children who are doing well are "surprises." More than 25 teachers are cooperating in the program and working hard with the computers.

This summer the Cherry Creek School District is offering a Logo program for gifted and talented students. Each student sometimes faces specific challenges, such as making a sprite carry his or her initials across the video screen.

Lexington Public Schools Lexington, Massachusetts

Beth Lowd of the resource center at Lexington Public Schools serves as a consultant to teachers using Logo. She reports that the use of Logo in Lexington is not a separate program in itself. Several teachers have begun to use computers with children of different ages. One sixth-grade classroom has had a Logo computer all year, as has one fourth-grade teacher.

The Lexington Schools see Logo primarily as part of the computer-literacy curriculum. Lowd describes Logo as both "a wonderful first programming experience" and "a very good tool for the child who hasn't been able to succeed in some areas."

While Logo is taught as a programming language, the children are also allowed to explore. Teachers use a checklist in connection with teaching Logo, but generally children learn a new feature of the language when they need that feature to achieve a desired effect. Children also trade a great deal of information. Part of the driving force in the sharing sessions is the children's desire to show their peers what they can do.

Next fall, the schools hope to have all fifth graders using Logo. If plans work out, the Lexington schools will provide each child eight whole-class lessons on Logo, with more than one hour a week using the computer. One Apple will be available for every two or three classes.

Driscoll School Brookline, Massachusetts

Driscoll School is training all fourth and fifth graders in the use of Logo. The training emphasizes programming and uses Apples and Terrapin Logo. Pairs of students get a half hour each week of computer time and use the computers all year long.

Joyce Tobias of Driscoll School reports that Logo instruction in the fourth and fifth grades has been successful enough to warrant writing a curriculum for the fifth and sixth grades to continue Logo classes. Each student in the existing Logo classes must achieve specific goals, first achieving each goal with help and later doing it alone. Boys and girls are showing equal interest in Logo.

Some children have passed graphics and gone into full-scale programming. Tobias reports that "one student is writing a Logo program that tutors other students in the use of Logo." Another boy is writing simulations, including one program that simulates taking a trip across the United States.

Queen's University Kingston, Ontario

Dr. William Higginson of Queen's University in Kingston, Ontario, says that about 15 schools in eastern Ontario are using Logo (see page 328). Interest in Logo is running high. The Educational Computing Organization of Ontario gave a conference in May

that drew 1400 participants. The program included 14 sessions on Logo.

Queen's University now offers a continuing education course to introduce school teachers to Logo. Classes meet one night a week for seven weeks. The univeristy is also developing a diploma program in educational computing. "Logo would probably be a significant part of that program," Dr. Higginson says.

Microcomputer Resource Center
Teachers College
Columbia University
New York, New York

Ursula Wolz reports that Teachers College is training teachers in Logo. Training in the field is taking place in New Jersey, New York's Westchester County, and New York City.

Also a month-long Logo course at Teachers College provides a two-week introduction to the programming language followed by a two-week practicum with an experienced teacher of Logo.

While Wolz believes that the use of Logo is an important part of education, she stresses that in order to be successful, teachers must have a good understanding of the developmental education concepts behind Logo. She believes it is equally important for teachers to have a strong working knowledge of Logo, noting that "teaching children Logo without really knowing Logo yourself would be like trying to teach Shakespeare without having read the plays."

The Teachers College Microcomputer Resource Center and the Department of Communications and Computing together offer an internship program for teachers. Teachers College also has Logo classes at its Center for the Gifted (classes are not restricted to the gifted). Wolz says one of the most exciting things about working with Logo is "seeing kids in their third or fourth session who have gone significantly beyond rudimentary Logo." She also enjoys seeing children sharing information and "working problems through as a group." Teachers College uses both TI-99/4s and Apples in teaching Logo.

A Final Note

Most of the people interviewed for this report did have one complaint about current Logo classes and projects: a shortage of machines and machine time for children. Under the circumstances, it is remarkable that so many early users and teachers are so enthusiastic about Logo. When we look back a few years from now, we will probably wonder how the pioneers in this field did so much with so little. ■

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Semidisk, Software Tools, the BDOS Blues, Power, and LISPs

A veteran computer user voices his opinions.

Jerry Pournelle
c/o BYTE Publications
POB 372
Hancock, NH 03449

First we had M-Drive, or Warp Drive, the Godbout/G & G Engineering system that tricks your 8085/8088 into thinking memory is a disk. Now we have Semidisk, which does the same thing and will work with any CP/M 2.2 system; unlike Godbout's M-Drive, Semidisk doesn't require a DMA (direct memory access) disk controller.

Semidisk comes in big chunks—512K bytes is standard, with a full megabyte on special order—and works with the S-100 bus. The firm says it'll have Semidisk available for the TRS-80 Model II and the IBM Personal Computer. I know Semidisk works with an S-100, either 8085 or Z80, because we have it running. We got it only yesterday; full report next month. So far it works fine and is comparable in speed to M-Drive. If you do a lot of programming with long compilations and assemblies, once you try either Semidisk or M-Drive you'll wonder how you ever lived without it.

Software Tools is one of those books you can't do without if you're serious about learning to program.

Software Tools

Not too long after Ezekial, my friend who happens to be a Z80 computer, came to live here at Chaos Manor, my (alas, late) mad friend Mac Lean brought me a book: *Software Tools* by Brian W. Kernighan and P. J. Plauger. Those were the days when I insisted I was monumentally uninterested in learning to be a programmer. "I only want to *use* the machines," I insisted. "I don't care how programs work."

"You'll want to learn," Mac Lean said. "So here's a painless way to get started. Read it. Hell, you know one of the authors."

It happened that I already admired Bill Plauger's work as a science fiction writer. Even so, I was reluctant to get started. Wisely, Mac Lean insisted—one of the many great favors he did for me and one of the countless reasons I'll continue to miss him for a long time.

(My wife says not to worry: sure as anything, some night I'll fall asleep at the keyboard, and in the morning, there'll be a disk file with a long diatribe on some totally unexpected subject, complete with telltale mad similes and the like. I can hardly wait.)

Software Tools is one of those books you can't do without if you're serious about learning to program. As Kernighan and Plauger say many times, you learn to write good programs by reading and studying good programs; and they show you a book full of them. The original edition of the book presents RATFOR (rational FORTRAN), an attempt to make a good language out of FORTRAN by adding conditional statements such as UNTIL, WHILE, CASE, and other requirements of structured programs. Way back in the book, they also give you a RATFOR precompiler that takes programs using the RATFOR conventions and turns them into reasonable FORTRAN.

The book is full of illustrative programs, and most of them are quite useful. The programs fit together into a set of "software tools," mostly for text processing, but also include a macro instruction expander and other items useful for programmers. Kernighan and Plauger's text editor is a bit out of date, but there's a lot in there that I thirsted for the instant I began to read the book.

There's a problem, though. Although I learned a bit about FORTRAN in the old days (1960s) and have Microsoft FORTRAN for my Z80, FORTRAN isn't really a very good language for microcomputers. Its string-handling capabilities are ghastly. There's no BEGIN. . .END construct to let you do several things following IF. . .THEN. The dreaded FORMAT statement doesn't make sense for today's input/output (I/O), and FORTRAN was really designed to work with 80-column lines, preferably from cards (so was Pascal; more on that later). The structure of FORTRAN, even with RATFOR, doesn't really encourage writing readable programs. It seemed to me that FORTRAN was a language whose time had passed, and I wasn't willing to in-

vest a lot of time in getting it running properly on Ezekial.

Neither was Mac Lean, and thus I read Kernighan and Plauger but never actually ran their programs. When the CP/M Users' Group put out the tools found in the book on one of the Group's disks, we made an abortive attempt to get FORTRAN running because this was, after all, back in the dark ages when there weren't many modern languages for microcomputers. You couldn't get C, and the only Pascal was the old version of UCSD (my son Alex, who's a senior there, pronounces that "Scud") Pascal. There was no LISP, Wordstar didn't exist, and a microcomputer version of PL/I was only a gleam in Digital Research's eye. There wasn't even an affordable FORTH. As I said, the dark ages. So we seriously considered RATFOR as the language to learn; but we had trouble hooking it into CP/M, and about then we became enamoured of Pascal, there being promised a number of microcomputer versions "real soon now." Thus, although I did try to get RATFOR going a couple of times, nothing useful came of it.

That disturbed me because the idea of "software tools" is a very good one. If you take a number of tasks, such as finding text patterns in files or archiving files, and build programs to accomplish these tasks in modular blocks, not only do you have useful programs, but you also have a number of procedures, subroutines, and functions you can lift out and put into other programs. You can incorporate the code into the source or keep the "tools" compiled in relocatable machine language for linking in. That way you don't have to reinvent the wheel every month or so.

It all sounded great, especially back then when I had more time just to play around. Every now and then I'd read *Software Tools* with a sigh of regret that I'd never got the tools running.

That's all changed now.

Now Unicorn Systems has formed a Software Tools Users' Group and, more to the point, will sell you the whole box of tools carefully rigged to run with CP/M. The firm also furnishes a lot of documents, including a tutorial.

Unicorn Systems has even put a Unix-like shell around CP/M. For example, if you want to use the FIND tool to scan the file SYSTEM.TXT for all instances of the word LOBO, you type:

```
FIND <SYSTEM.TXT LOBO
```

and all lines in the file SYSTEM.TXT containing the word LOBO will appear on the console. Note the <, which indicates input source. If you typed:

```
FIND <SYSTEM.TXT LOBO
>FOO.DAT
```

then the program would create file FOO.DAT and put the output into it. Very convenient, and there's a whole raft of Unix-like extensions and features built into the shell. It would take most of the column to describe them all.

In addition to the tools and the shell that make CP/M friendlier, you get a spelling program and, of course, RATFOR, including the source code,

which is written in RATFOR. With the Unicorn package and a FORTRAN compiler, you could write a lot of awfully useful programs.

The Unicorn package is a class act: a thick loose-leaf binder full of fairly well organized information and 2 plastic boxes that contain 15, count them, 15 disks of software tools and sources. Incidentally, the system *will not* run on CP/M 1.4; you *must* be using 2.0 or a later version.

A few years ago I'd have been slavering for a chance at something like this. So, when at the West Coast Computer Faire, Deborah Sherrer, the principal author of most of this, gave me the choice of carrying the package home on an airplane or having it mailed to me, I chose to carry it, bulky as it all was, rather than chance losing it. But, alas, the excitement turned out to be residual; when I got home, I didn't do much with it and haven't yet.

And that's sad. Unicorn Systems has gone to a lot of work to produce something useful, well packaged, well documented, and bug free, and to try to write it up so that beginners can understand it. It succeeded too. Companies like it ought to get all the encouragement this profession can give them, and I hope it sells a lot of its packages. Lord knows Unicorn Systems is charging no more than a fair price. But. . . .

The problem is that I still think both RATFOR and FORTRAN are languages whose time has passed, especially for microcomputers. Thus, while the Unicorn package plus Kernighan and Plauger are terrific for teaching RATFOR, I can't recommend spending much time learning it. It's outdated.

And so, I fear, are most of the software tools. The Kernighan and Plauger editor beats the daylights out of CP/M's ED, but then what doesn't? ED is only a little better than a Selectric II typewriter. The Software Tools editor was great in its day, but it's line-oriented, not full screen, and anyone who's using a line-oriented editor in this day and age probably chases down geese to get the makings for fountain pens. Some of the other tools, like FIND, are useful; but ye gods, FIND.COM is a 29K-byte file, and it doesn't run very fast, either. Ditto for most of the other tools: too big, too cumbersome, too slow—and written in the wrong language.

If you really want to use Unicorn's Software Tools—and they are indeed useful foundations to build on—then you probably want them in a language you speak, not in FORTRAN.

Software Tools in Pascal

Which brings me to a mild conflict of interest, so I want to make sure you all understand a possible bias on my part.

In my judgment, Unicorn has done a great job, and I really encourage it. But if you want the Software Tools, my recommendation is that you build your own set in Pascal or C. Kernighan and Plauger have put out *Software Tools in Pascal*, a book functionally identical to the original (all the old programs are in it, except, of course, the RATFOR compiler). My son Alex has put together a disk of the first couple of chapters' worth of the programs together with the primitives and inclusion files needed

to get the Tools running under either Sorcim's Pascal M or Digital Research's Pascal/MT+. He's added the introductory programs from Peter Grogono's book *Programming in Pascal* (Addison-Wesley, rev. ed., 1980), and then he and Barry Workman ganged up to induce me to add my own comments. The result, called the Pascal Introduction Package, isn't anywhere near as complete as what Unicorn Systems furnishes. If you want *all* the Software Tools to run in Pascal, you'll have to type in a number of them yourself; but that's the way I recommend you go, because with the Workman package you learn a language you can build your own tools with.

However, Unicorn does give you a nifty CP/M shell you can use to get the feel of Unix, and of course, there are all the tools and some interesting extensions already compiled and ready for use. If you do plan to use FORTRAN in the future, the Unicorn deal is the best bargain in town.

The Hollerith Card Blues

A while back I mentioned that FORTRAN expects its input from 80-column cards. If you use Unicorn Systems' package of Software Tools on text files created by WRITE, Wordstar, or Magic Wand, then what the Tools think is a line can cause some pretty strange results. Alas, it's true for many other languages. We will regret the legacy of the Hollerith card for a very long time.

Take Pascal as an example. ISO (International Standards Organization) Pascal has no strings at all. Most implementations put in strings as an extension, but they do it in a way that cripples the language. Pascal M and Pascal/MT+ follow the UCSD Pascal system in which the longest string possible is 255 characters. There's nothing you can do about it because these Pascal implementations store the string length as a single byte put in front of the string. The input situation is even worse: microcomputer versions of Pascal can't grab lines longer than 255 characters, and, indeed, the implementations I'm familiar with truncate line inputs to 80-character lines unless you explicitly tell them differently.

None of this is a problem for text processing if you're using a line-oriented editor with each line 80 characters long terminated by a NEWLINE (which in ASCII is also a problem because that's two characters not one, but we'll leave that for another time). Suppose, however, you want a modern full-screen editor, one which leaves the line lengths variable and marks only the ends of paragraphs. For example, one like WRITE, the editor I use. What now?

Well, of course you can get around that, and Alex shows how in his Pascal Introduction Package. He gives you two ways. Neither is very elegant, but we don't know any elegant methods. One way is to get your input one character at a time, which works fine but slows things down a lot. The other is through a small machine-language program that "standardizes" your text files by making a copy with paragraphs broken up into lines of 80 characters or less, using different characters to mark the (artificial) line endings from those used to mark paragraph endings. This grabs WRITE, Electric Pencil, and Magic Wand files and runs about as fast as CP/M's PIP. The various Pascal tools run *much* faster on files passed through this filter because the programs can now get their input by "lines."

Or you can shelve it all and learn C, or even Digital Research's CB-80 (the compiling version of CBASIC). We've done a few preliminary comparisons of CB-80 and Pascal, and they're closer than I expected on both speed and final program code size. We're doing some experiments on that, and we'll have the results in a few weeks.

One reason Alex didn't try CB-80 sooner was that CB-80 had a ghastly license agreement that required you to pay $2000 a year *upfront* before you could sell programs compiled with the language; but the company dropped that some time ago.

CB-80 has some terrific advantages for text processing: it can read a "line" of up to 31,000 characters in length, yet you don't have to dedicate

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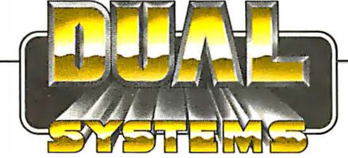
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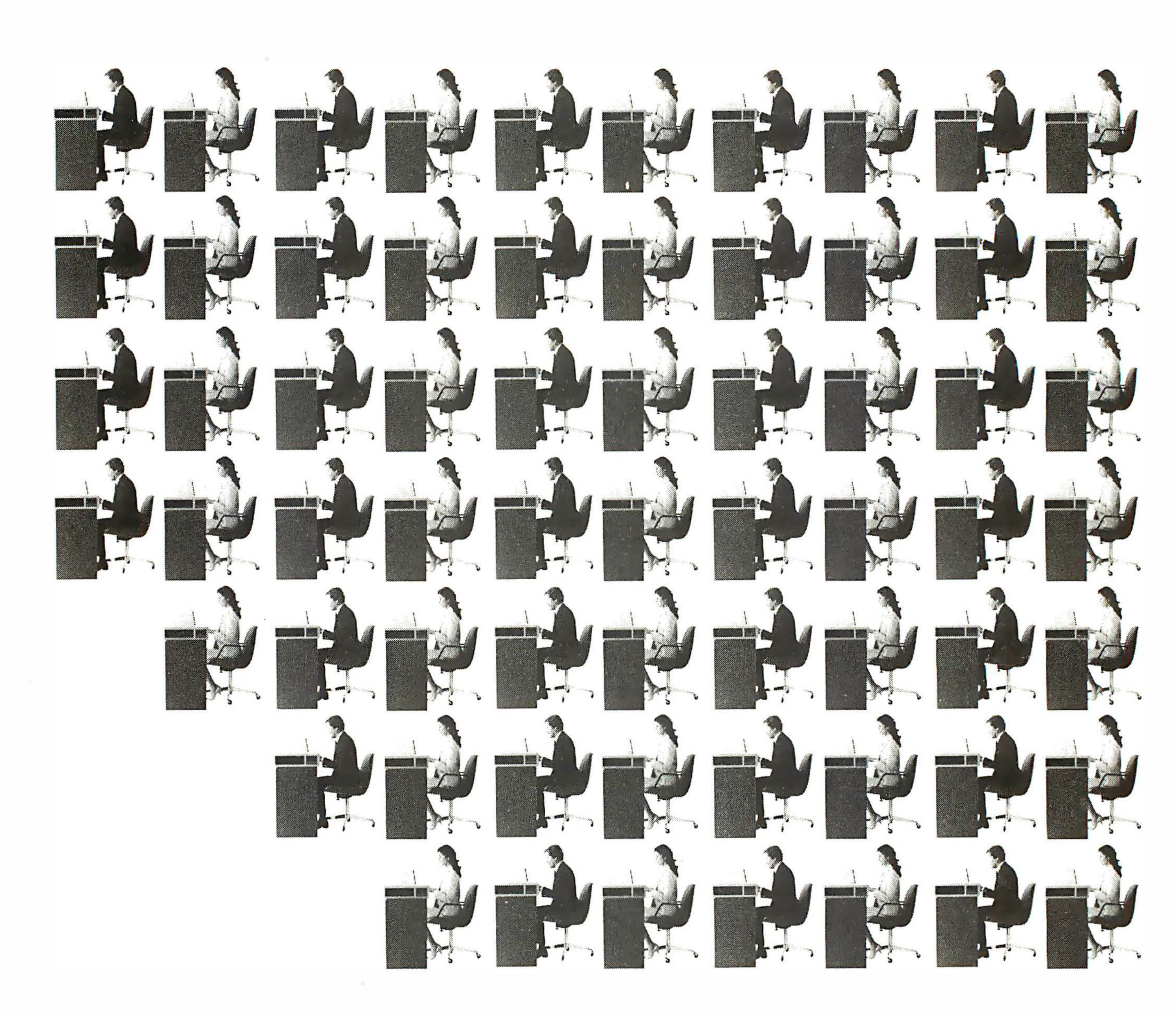
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0 to 60 without shifting

an enormous buffer to do that. CB-80 takes care of that dynamically, so that all you must have is enough free memory to put the string in. The program then grabs everything up to and including the carriage return and ignores the linefeed character at the end. Now that the licensing of CB-80 is rational, I predict a rash of text-processing programs using it.

I showed this column to Tony Pietsch, and he got another brainstorm: a way to overlay WRITE so that it will put out text in any format you like, including lines of 64 or 80 characters terminated by a cr-lf (carriage return-linefeed) pair. I wouldn't be surprised to have that in a couple of weeks; when Tony gets to working, he works hard.

Good Stuff at Low Cost

The idea of software tools has wide appeal, and I presume that the Kernighan and Plauger book was responsible for Walt Bilofsky's naming his company The Software Toolworks. From the address I know that he's a neighbor, but in fact I never met him until the West Coast Computer Faire.

Bilofsky began by filling a much-needed niche as supplier of programs to the Heath market (he later converted them to CP/M), and it shows: many of his programs run best with a Z-19 terminal, and some, like his graphics package, won't run without one. (Lately, though, he's gotten heavily into programs for the Osborne 1.)

Bilofsky sells a wide range of programs, all at low cost (generally under $50). All the ones I've tried are excellent. His Ed-a-Sketch for the Z-19 (and the Osborne 1), for example, will let you draw and save all kinds of fancy stuff. His PIE full-screen editor (also only for the Z-19 terminal), while no Magic Wand or WRITE, is certainly more than worth the $29.95 he charges. I haven't tried his spelling checker ($49.95 with 50,000-word dictionary equivalent; it runs on the Osborne 1), but if it works as well as his other software does, it has to be a bargain.

He'll also sell you Eliza, that rather stupid psychiatrist program, for $24.95 (CP/M or Osborne). You'll get tired of Eliza pretty quickly, but it is a nice thing to have next time someone asks you to demonstrate your computer at a party.

There are also games (including Mychess for the Osborne), a LISP interpreter, a C compiler, and more to the point of this column, languages, including RATFOR for Microsoft FORTRAN (keyed to the *Software Tools* book). I somewhat prefer Zolman's BDS C (B. D. Software C), if for no other reasons than the extensive documentation and library utilities that come with the BDS package. But the Software Toolworks program compiles to 8080 assembly language, meaning that you can get in and hand-optimize important loops if you need to. It's fast, and I may well end up writing some operating utilities in it.

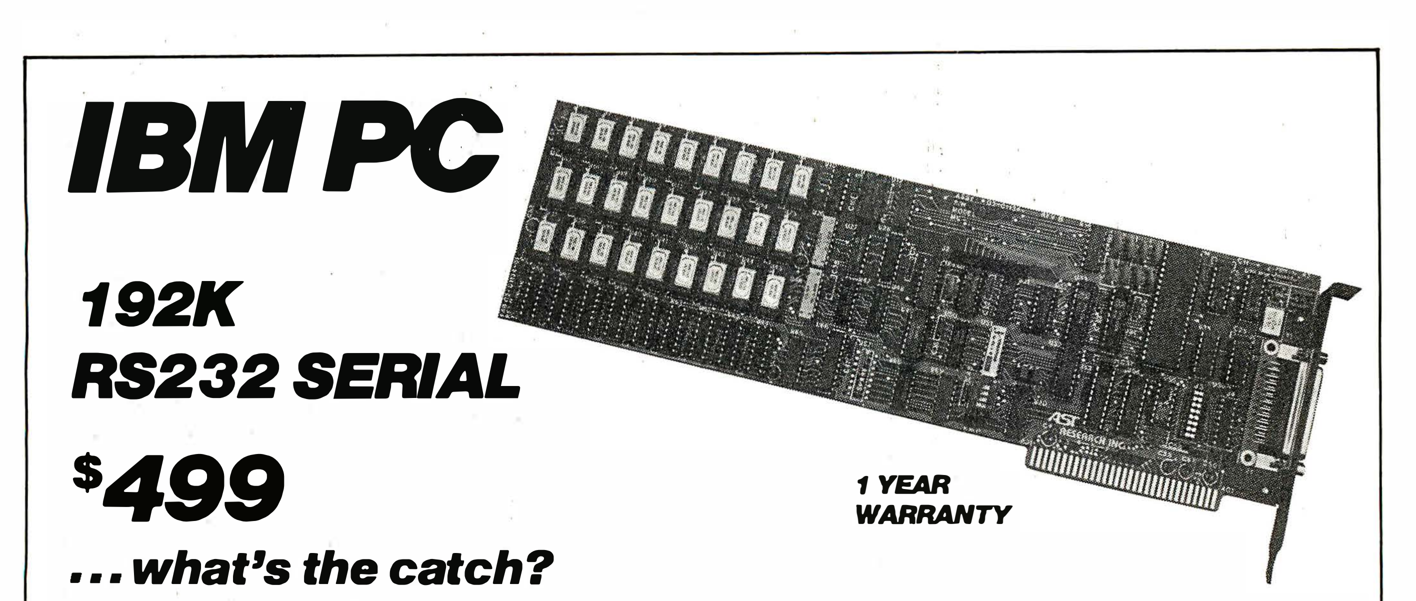
Things have been a bit hectic here at Chaos Manor, so we haven't had a chance to try all of Bilofsky's programs; but we've tested several, and all work as advertised. I strongly recommend his philosophy and approach. By all means get his catalog; for sound programs at very reasonable costs, Software Toolworks is hard to beat.

One Strange Bug

I can't think of anywhere else to put this. If you don't use CBASIC, you can skip this section.

I've written my Journal program in CBASIC. It compiles fine on Ezekial, who runs CP/M 1.4 at 2 MHz. But when I tried to compile the exact same program on the Godbout 8085/8088 (running at 6 MHz), I got the goofiest errors you have ever seen. Things like "BDOS ERROR ON X: Bad Sector," and no, the "X" is *not* a misprint. And sometimes the compiler would just keep running: it would reach the end of the program and start right over again. Transfer the disk down to Zeke and no problems; put it in the Godbout and get nutty error messages or infinite loops.

Eventually I solved the problem. First, on a Godbout 8085 running CP/M 2.2x at 6 MHz, the END statement to terminate a CBASIC program is *not* optional. Always include it; it helps the compiler find the end.



Take a good look. This is the face of things to come. On one board in one slot, you get 192k of additional memory and a serial printer port. If you look close you will see the board has room to expand to 256k. You can even add another parallel port. And if that is not enough, by the time you read this we will have added another useful option — a real time clock.

IBM DIDN'T MAKE IT SIMPLE

Well that's good, because simple usually means limitations, and so far we have not found a lot of limitations. It is hard to pick IBM cards when you have only five slots. Now lets see. If you want graphics and color you buy one board. And if you want a printer port you buy another. Or you buy a monitor adapter and you get a printer port on the same board. When you want to add serial communication it's another board. Add some memory at 64k per board. Wait a minute. Thats two plus one, plus one, plus one more, minus one if you don't want graphics — HELP!! Your PC is now a mass of boards and you still want to do more. Not only that, but you now have spent so much money on boards you may have to compromise somewhere else in your system.

A QUICK SURVEY

We decided the answer was a board that could do several jobs and use a single slot. First we called IBM to find out what kinds of boards and accessories are sold in what percentages. Wrong question. You would have thought we had asked what was on the missing 18 minutes of the Watergate tapes, because that's what we got — a long silent pause. The official answer was "that information is not available to non-IBM people." So we started calling dealers and asking them. Turns out that about 85% of the systems they sell have the monitor board with the printer port. The next most popular item is the asynchronous serial board, and then memory. Almost all of the salesmen we talked to tried to tell us we didn't want IBM 64k memory boards, and they would be happy to sell any number of aftermarket boards for prices ranging from $795 to $1195. A.C. Nielsen would be proud.

HOW IT'S DONE

Land. Printed circuit area is called land. If you have enough land, and you are real clever in how you use it, you can "grow" everything you want on one board. In this case we have enough land to do all the popular things. First 192k. This combined with the 64k in the PC gives you 265k. Just the right number. Count 'em. Nine per row of 64k bit chips so you get parity checking. Our board comes standard with an RS232-C serial port. All of the good things like solder masking, silk screening of parts locations, and of course gold plated connectors are standard. Each board is tested and burned in.

For an additional $50 you can get a second printer port. You choose, either serial or parallel. On the little land we have left we are adding a real time clock which you can have for $50. You can put in your own row of chips to increase the memory to 256k, but we won't warranty your row of chips. For $100 we will add them to the board, test, burn in, and warranty them.

AN OFFER YOU SHOULDN'T REFUSE

One of the best things you can use the PC for is a spreadsheet program like Visicalc. That's how we figured out exactly how much this board cost us to build and how much to sell it for. Then we discovered Supercalc. All the things we liked about Visicalc are in it, and all the things we did not like are corrected. It addresses all the memory (256k), and in fact will address 512k if you have it. Now the offer. If you buy the package from us, the board and Supercalc, it will only cost you $675. Look around. You don't have to take our word for it. But you should. The offer is only good if you buy them both at the same time.

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Second, always end the program with no fewer than five carriage return/linefeed pairs. You *must* have at least one at the end of the program, or it won't compile at all. But for my fast machine, it turns out that if one carriage return/linefeed pair is good, more's better, and about five keep the errors away. I haven't a clue as to why this works, but it does.

Them Old BDOS Blues

I suppose I don't have to say that all in all I like CP/M; but there are times when I grow very weary of its flaws. It gets particularly annoying when there might be a hardware problem. "BDOS ERROR ON B: Bad Sector" (BDOS stands for basic disk operating system) isn't very informative when you know you can get that message because of any one of a dozen reasons.

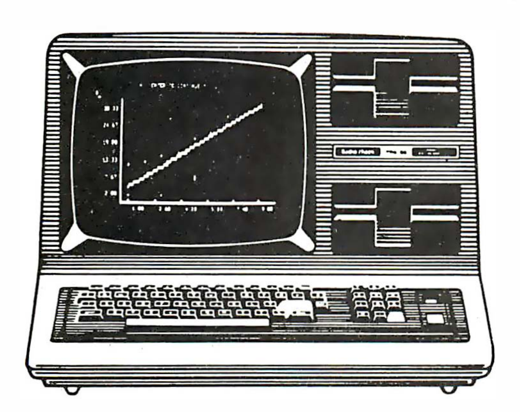
I suppose one reason CP/M hasn't annoyed me as much as it does most people is that I've always had Tony Pietsch's protective software. Ezekial, for example, has a very large PROM (programmable read-only memory) monitor that looks at everything and has complete diagnostic messages. Thus when I forget and leave Zeke's drive doors open and try to save something, he says, "PLEASE CLOSE DRIVE DOOR." When I close the doors, he goes on as if there'd never been a problem.

Unfortunately, the CBIOS (customized basic input/output system) supplied by Bill Godbout with his 8085/8088 isn't anywhere *near* that friendly, as I found out while doing my taxes. I was entering stuff into my journal, which is a CBASIC program, and my wife called me to dinner. I didn't expect to be long—during tax time at Chaos Manor *everyone* avoids me—so I opened the drive doors and left the Godbout running. When I returned I made some more entries, then tried to save the enlarged



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file. Like an idiot, I used the same filename that I'd used before. And, alas, I hadn't closed the drive doors.

"BDOS ERROR ON A: Select Error," it said to me. "Bah," I replied. "It's an open drive door." And unthinkingly I closed the drive door. Whereupon it proceeded to completely clobber my file and thoroughly crash the system.

Fortunately, I'd thought of that one long ago when I wrote the Journal program: the actual entries are in files called "JORNL-21" and the like, while the first thing the program tries to write is a summary file called "JRSUM-21" that contains only summary stuff like the number of entries and heading data. It's easy enough to recreate the JRSUM file and thereby save the data in the JORNL file. But it's still infuriating to have to do it.

"You've had it too easy," Tony said. "You're used to my software."

"I know that," I said. "But what do I do *now*?"

"Well, I've done a new CBIOS for the Godbout. . . ."

Meaning that open drive doors no longer crash my system. I'm encouraging Tony to send a copy of the new CBIOS to Bill Godbout so others can have that benefit also. I hope he'll do it. The only problem is that he doesn't want to maintain the thing and answer hundreds of questions from users.

He's also taken care of the problem of open doors in WRITE (Writers' Really Incredible Text Editor), which he keeps improving monthly. With WRITE, you can leave the drive doors open, change disks, put in full disks, and put in disks with bad media, and WRITE still recovers.

Or tries to. The problem is that Tony can't be responsible for your CBIOS, and if that's not well written, there may not be anything the program can do.

There are only three error messages in CP/M: "Select Error," meaning that the system can't find the drive it's trying to write to; "Bad Sector," meaning that it can't perform whatever operation it's trying to do, like read or write a sector; and "R/O," which means that the directory doesn't match the bit map. That may be because you didn't press Control-C after changing disks, but "R/O" sometimes means either the disk or the directory is full.

None of these errors should be fatal. With careful study of CP/M you *ought* to be able to return control to your program. Tony catches stupid errors, such as open doors and the like, in the CBIOS, and the people at Sorcim told him how to let programs recover from other BDOS errors. Unfortunately, most programmers don't know enough about CP/M to catch stupid errors, and CP/M documentation, including all the books I've seen on the subject, isn't helpful.

The trick—which is *not* supported by Digital Research and, in fact, is specifically forbidden in the CP/M documentation—is absurdly simple. In CP/M, location 00 has a jump instruction, and the address of the "warm start" (the place in memory you go to do the equivalent of Control-C) is in locations 001 and 002. The Digital Research documents say that this *must* be left unchanged; but in fact, CP/M 1.4 and 2.2 *never* call that location unless there is a BDOS ERROR.

All of which means that a clever programmer can snatch that warm-start location, store it, and put the address of an error-trap routine into locations 001 and 002. On exiting the program, you put the warm-start address back. If none of this makes any sense to you, don't worry about it. What I'm doing is giving out some underground information for those who can make use of it. I repeat, this is not supported by Digital, and there are no guarantees that future releases of CP/M (or MP/M) will be compatible with this recovery method.

Also, if your CBIOS is incompetently done, then clever programmers can't compensate. Alas, there is more than one incompetent CBIOS floating around. There are even companies that won't give you the source code of your CBIOS. If you've been unfortunate enough to get yours from one of those companies, you have my sympathy and advice, which is to think again before dealing with a company that withholds vital infor-

mation. The CBIOS matches your particular hardware to the general CP/M operating system, and if it isn't well done—or if you can't modify it—then you can be in big trouble.

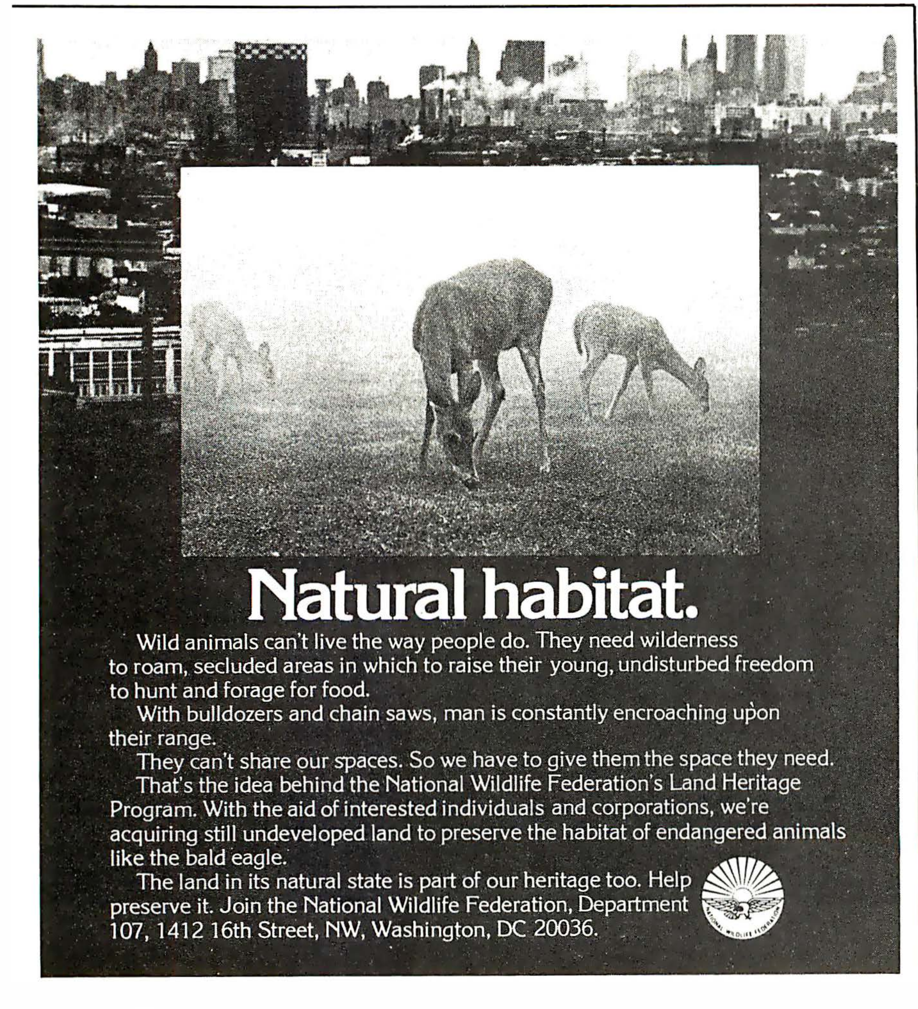
The potential for error recovery is inherent in CP/M because the bit map, which tells precisely where the various chunks of your file are hidden, and the directory are right there together. Both are updated quickly and efficiently each time you go Control-C, or each time your program makes the appropriate call to accomplish the same thing. WRITE, for example, does the equivalent of Control-C before *every* read or write operation; thus it's always working with an up-to-date bit map and can cope with changes of disk and the like. (Remember, Tony put WRITE together from specs furnished by Larry Niven and me; and we're very paranoid about losing text, so WRITE is extremely defensive. Since Larry and I often write with, uh, lots of brandy for the coffee, WRITE has to be tolerant of operator errors as well.)

But despite the fact that clever programmers can overcome many CP/M flaws, we still have a problem: CP/M, our de facto "standard," has holes you can drive a truck through. The question before the house is, "Is Digital Research doing anything to fix them?" When we get our 16-bit and 32-bit machines, must we endure more "BDOS ERROR ON X: R/O" when we know darned well the disk isn't Read Only because we physically removed the write-protect mechanism from the disk drive?

CP/M is a good operating system; but there are some improvements needed. We can hope Digital Research will make them. If not—well, think of it as evolution in action. . . .

Utilities

I hope CP/M cleans up its act. Meanwhile, I have a temporary solution to some of the problems.



First, if you're not getting the public-domain CP/M utilities, either "raw" from the CP/M Users' Group or "filtered" through someone like Barry Workman, you ought to do something about it.

And more good news: CP/M will give you a reasonably well formatted directory *or* tell you file sizes; it won't do both. You can, however, get XDIR or XD, which will. Both have long been available from the CP/M Users' Group, and Workman furnishes versions for both 1.4 and 2.x on his Utility Disk One. But there's better news.

Tony Pietsch has just written a real doozy of an XDIR that lets you put in wild card characters (XD *.FOO will list all and only those files with an extension of FOO), optionally allows you to alphabetize by extension (it groups all the .ASM files, then the .COM files, etc., with the filenames alphabetized within each extension), tells you the number of kilobytes each file takes up, tells you what user number is logged on, will show you the directory of *another user* without your having to log on as that user, tells you how many directory entries and how many kilobytes remain on that disk, and does it all speedily and efficiently. It's the equivalent of STAT in usefulness and reliability. There's even an XD.DOC file you can call for help. I can't imagine how I got along without it. Tony wrote it for me, Larry, and himself. You can get it and other programs from Barry Workman on his Utility Disk Four.

Then there's Power, which comes to you from an outfit with the cutesy name Computing! The exclamation point is part of the firm's name. I wonder, is it trademarked? For that matter, some day I suppose I'll wake up to discover that my own name has been trademarked—by someone else. In any event, at the West Coast Computer Faire the utility was called CPMPower, but since then the company has changed the name of its package because of legal complications, and it is now called Power.

Incidentally, the "licensing agreement" for Power makes more sense than most do. Computing! disclaims any responsibilities, of course, but

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simultaneously demands only that the user not redistribute the programs. It doesn't ask the buyer to restrict use to one machine.

One of the things Power claims to do is intercept the horrible "BDOS ERROR ON A: Select Error" message if you leave the drive door open. Unfortunately, if you follow the instructions to test this feature, you get the same old BDOS ERROR nonsense that you always get. The document says "NOTE: Error trap flag must be set at 10D Hex if your CP/M system accommodates this feature. (See CUSTOMIZATION.)" On turning to CUSTOMIZATION (which I had trouble finding; there's no table of contents, but fortunately CUSTOMIZATION is where the index would be if the document had one), I found no explanation whatever but an assembly listing that told me:

```
010D  00  ERRTRP: DB 0   0=not,
0FFh=trap hard disk errors
```

If you can tell me what that means, I'll give you sixpence. So I haven't the foggiest whether some kind of magic manipulation (such as setting 10D to something other than 0) will intercept the BDOS ERROR or not.

Once I got Power transferred onto my master disk (it's a 12K-byte program with a 6K-byte overlay), I played around with it. It's got some nice features. For example, there's a kind of mini-monitor built into it. You invoke Power, and not only can you do all the usual CP/M things like TYPE and STAT and REName, but you can dump, display COM files as hexadecimal numbers with ASCII messages out to the side just as DDT (the CP/M debugger) does, fill memory, search memory (but alas not search files) for a given text pattern, set DIR and USER number and all that stuff, go to a certain memory location, load and execute programs at *any* memory location, etc.

In other words, the program overcomes some of the limitations of CP/M. Of course, many of those are limitations only to hackers; most users aren't terribly interested, especially at the memory cost Power exacts. You'll also pay another way: Power lists the directory in two columns that aren't in alphabetical order, so that if you use double-sided double-density disks with lots of files on them, you'll go nuts trying to find the filename you're interested in. To compensate, though, Power will assign a number to each filename on the disk, and to copy a file, you only have to type its number, not type (or, as they say, mistype) the whole filename. The same is true when erasing something. The bad news is that you *must* use the menu number, and it probably scrolled off the top of the screen before you caught it.

Another feature of Power is that you can reclaim lost files; this is especially helpful if you've inadvertently typed "ERA *.BAS" when you meant "*.BAK". Power will get all those .BAS files back for you. Unfortunately, the documentation does not explain that large files may be reclaimed improperly under certain circumstances.

There are a lot of other features, including the ability to read and write to disk by sector and track, which means that if you knew what you were doing, you could use Power to recover files from disks with messed-up directories. Power also claims the ability to operate without having a system disk in either drive.

All in all, Power looks useful, and I'm glad I have it. I'm even gladder of Tony's XD and some of the Workman-CP/M Users' Group utilities. I'd probably be even gladder of Power if the documentation were a bit clearer, and I'd like a bit more explaining of what Power does and how it does it. I suspect Power is more useful to hackers than users. It's obvious the writers understand CP/M very well indeed; I wish they'd shared a bit more of their knowledge.

Again, LISP

We recently had our big L-5 Society Conference on Space Development here in Los Angeles, and two of our speakers were John McCarthy, who wrote LISP back in the fifties, and Marvin Minsky, who designed and built the LISP machines used at MIT. (Plug: help the space program. Join the L-5 Society. Send $25 to L-5,

1060 E. Elm, Tucson, AZ 85719. Do it now. I'll wait.)

As I've noted before, LISP has become *the* language of the artificial-intelligence community. Moreover, a number of LISPers have taken up my challenge and shown me all kinds of useful programs written in LISP: accounting programs, library programs, and the like, all with really good user features like self-prompting and error trapping. I confess I'm impressed with what you can do with the language.

Walt Bilofsky says LISP is the ideal breadboard language; once you know it, you can do things quickly and without fuss, as long as you're not after elegance. After all, no one complains if a breadboard layout has resistors sticking up in the air and cut traces.

I'm also impressed at the chaos you can create; LISP programmers really and truly do go around handing each other lines of code and saying gleefully "I bet you can't tell me what *that* does." But I've long since conceded that if you're interested in artificial intelligence, you have to learn LISP, and if you expect to make a living in the computer world, you probably ought to avail yourself of any opportunity to learn LISP because there are some things you can do with it that you can't do elegantly in any other language.

Software Toolworks' LISP will let you play around with the language to find out if you're really interested.

The problem has been that there aren't many LISPs for microcomputers. That's still true, but I have received two more, one of which on first inspection may be the best of the microworld's LISPs, while the other is certainly the cheapest. The first is from Supersoft, and it looks to be more complete than the Microsoft LISP originally developed by the Soft Warehouse. The Supersoft LISP resides partly in memory and partly on disk, using swapping overlays as needed. Obscure user-defined functions can be kept on disk, leaving lots of free memory.

This allows Supersoft LISP to have full recursion—that is, a function may call itself any number of times. (Well, I presume there is *some* limit, but it's a pretty big number.) Because recursion is a standard, indeed vital, LISP feature, this makes Supersoft LISP pretty powerful. Supersoft claims its LISP is a full MIT LISP 1.5 with extensions. Because I'm not a LISP hacker (although I am getting more and more interested in the crazy language), I can't verify that. I do know mine works. Some functions are a bit slow due to the need to call in overlays from the disk, but put all that on M-Drive or Semidisk, and it really wails.

The Supersoft documents are complete in that they describe each function in the language, but they're not very good. There's no index and no

Items Reviewed

CB-80 (compiler version of CBASIC) — $500
Digital Research
POB 579
Pacific Grove, CA 93950
(408) 649-3896

Power — $149.95
Computing!
2519 Greenwich St.
San Francisco, CA 94125
(800) 227-3800, operator 28

LISP — $39.95
The Software Toolworks
14478 Glorietta Dr.
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(213) 986-4885

LISP
Supersoft
POB 1628
Champaign, IL 61820
(217) 359-2112

CP/M version	$150
TRS-80 cassette version	$75
TRS-80 disk version	$100

Pascal Introduction Package — $50
and
Utility Disk Four — $32.50
Workman and Associates
112 Marion Avenue
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(213) 796-4401

Software Tools for CP/M — $325
Unicorn Systems
30261 Palomares Road
Castro Valley, CA 94720
(415) 881-4490

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Semidisk Systems
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512K bytes	$1995
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manual only	$10

WRITE (Writers' Really Incredible Text Editor) — $395
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9929 Jefferson Ave.
Los Angeles, CA 90230
(213) 204-5570

Books Reviewed

Software Tools — $14.95
Brian W. Kernighan and P. J. Plauger
Reading, MA: Addison-Wesley Publishing Company, 1976

Software Tools in Pascal — $15.95
Brian W. Kernighan and P. J. Plauger
Reading, MA: Addison-Wesley Publishing Company, 1981
(617) 944-3700

real explanation of what LISP is; to learn the language you'll need a lot more than Supersoft furnishes. Some of the discussions are completely opaque. On the other hand, I'm not convinced you can learn LISP from books anyway; I think you need tutorial help.

Supersoft furnishes everything you'll need, like a tracer. The hooks into CP/M are reasonable, or at least not unreasonable. (But there's no implementation of a random-access file; you'd have to write that in LISP yourself.) Again I emphasize that you'd better know what you're doing

because the explanations on using LISP with CP/M are terse beyond belief. Ditto for the section on "Machine Representation of LISP Objects." I expect it all makes very good sense to Minsky and McCarthy, and indeed every now and then I understand a line or two; but one should read this manual with a book like Winston and Horn (Patrick Henry Winston and Berthold Klaus Paul Horn, *LISP*, Addison-Wesley, 1981) firmly in hand.

With that warning, I can recommend Supersoft LISP.

If you just want to get a feel for the language, you can try Software Toolworks' LISP at $39.95 for either Osborne 1 or any 8-inch CP/M system. This one was written in C and is somewhat slow, but it is fairly complete. The documents are better than Supersoft's. Software Toolworks' LISP will let you play around with the language to find out if you're really interested. How can you pass it up at the price?

Immortal Paperwork

I often get letters asking why I haven't reviewed one product or another. Often the suggestions are very helpful. But, there's a ton of software around here; lately everyone has been sending me stuff to review. I'm very grateful, but I do sometimes feel guilty about not getting to everything as quickly as I should.

One difficulty is that I have had two systems: a Z80 running CP/M 1.4 and an 8085/8088 running CP/M 2.2. But people kept sending me software that requires a Z80 running CP/M 2.2. Eventually I solved that problem: I got another computer. Next week we'll set up a Z80 running CP/M 2.x, and we'll reduce the size of that pile of unreviewed software that menaces me from the corner. We'll also be able to install Semidisk, which just arrived.

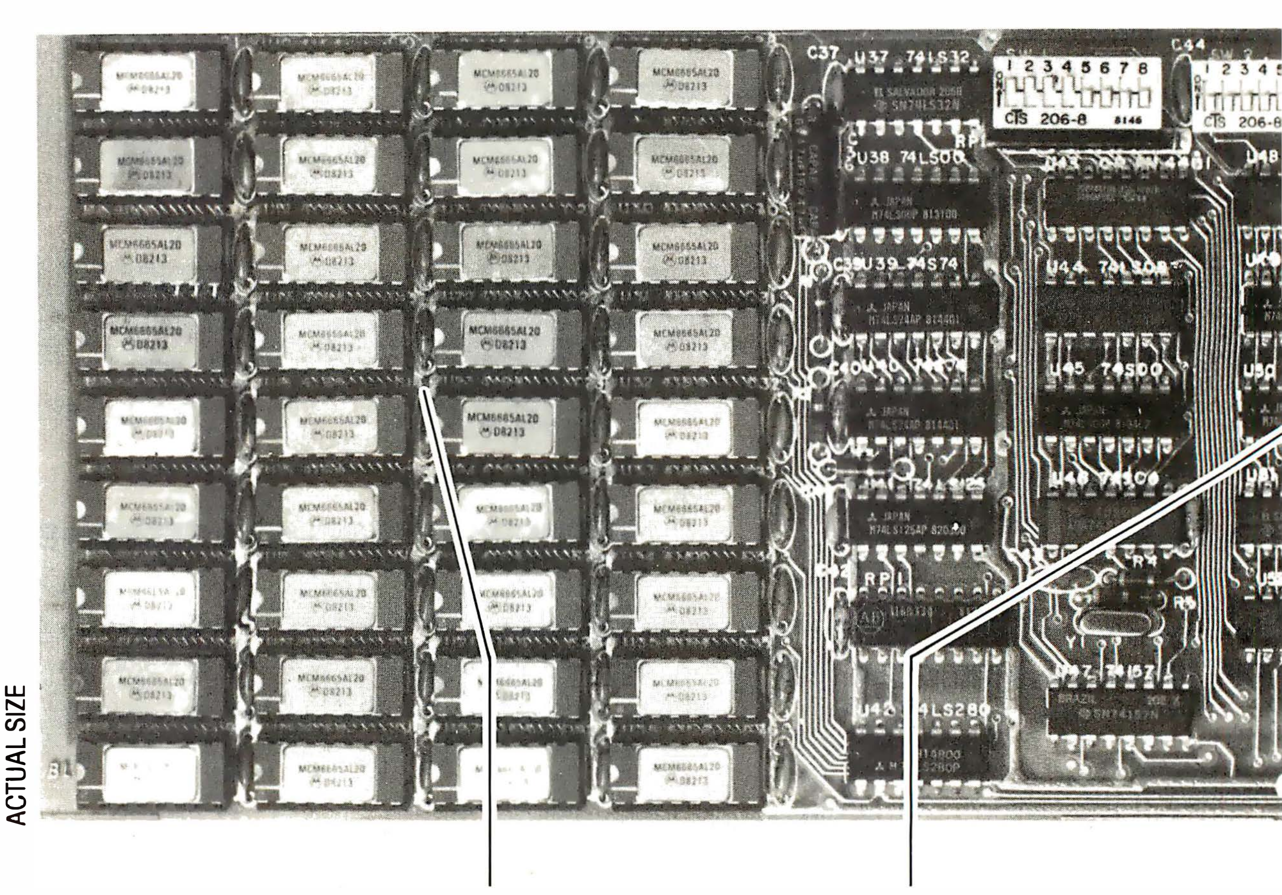
Meanwhile, I'm working on not one but *two* computer books. One will be in loose-leaf format and contain all my back columns (updated and revised as necessary) plus my fulminations about famous brand-name equipment, what hardware I *really* can't stand, and random walks around Chaos Manor—in other words, much like these columns. Since it will be topical, it'll probably need revising fairly often. That means small print runs, so that (1) the price will have to be outrageous, around $18 postpaid, and (2) I will want to keep it close to me and under control, so I'll let Barry Workman handle it. It may even be available by the time you read this. The other book is for a major publisher to be pitched at a mass market; BYTE readers may find it interesting, but you'll be more likely to give it to someone who asks you about computers (at least I hope you'll want to do that).

So, what with the books, getting the new Z80 system running, the pressure of being chairman of the Citizen's Advisory Council on National Space Policy, finishing *Janissaries II: Clan and Crown*, and working with my partner Larry Niven to finish *Footfall* by next spring, it's amazing I get these columns written at all. But I do thank everyone for letters and suggestions, and I try to answer as much of my mail as I can. If I owe you a letter, please have pity.■

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The Commodore 8032 Business System

Harold Dickerman
POB 355
Sharon, MA 02067

Commodore has introduced a new microcomputer for the small-business market: the Model 8032. Inside the 8032 is a new operating system that makes up for some of the deficiencies of Commodore's old operating systems. Also available is a version of this new operating system for Commodore's older machines.

Commodore has also upgraded its dual floppy-disk system, now called the 4040. It is used with an improved disk operating system (DOS), which is more reliable and can now randomly access disk files. Commodore has also released the 8050, a dual 5¼-inch floppy-disk-drive system with 500K bytes of storage per drive. Although the 8050 drives are single-sided, they allow double density and 96 tracks per inch. The disk operating systems for the 4040 and the 8050 are similar and the commands are basically the same. Any comment about the 4040 is usually applicable to the 8050 as well.

The release of this new equipment is accompanied with new software that makes this Commodore Business Machine (CBM) truly a professional piece of equipment. With a combination of software packages (not produced by Commodore), this microcomputer system will find its way into both small and large businesses.

New System Features

First, a look at the 8032. Its new 80-column, 12-inch video screen is the most obvious difference from Commodore's other systems. As before, the system's cabinet is a one-piece housing for the main logic assembly (the circuit board on which the system is built), power supply, video display, and keyboard. The clean design makes the system aesthetically suited for residence in an office.

The main logic assembly runs the depth of the cabinet, with the power supply at the back left corner and the video circuitry mounted above. Heated air is allowed to rise upward, out of the cabinet, while cooler air enters through the bottom; a fan is unnecessary.

All interface circuitry is built into the system. It is accessible by way of three edge-card connectors at the back of the cabinet. This includes the famed IEEE-488 interface that allows the computer to control test equipment (among other things), the user parallel port, and one of two cassette ports. The memory-expansion port can be accessed through an opening in the side of the machine.

One of the features for which the old PET microcomputer was known was its real-time clock; thankfully, this feature is included with the 8032. For high-level-language use, this 24-hour clock reads out hours, minutes, seconds, and "jiffies" (sixtieths of a second). Through machine language, resolution down to 1 millisecond is available, making the system suitable as an instrumentation controller. Software has eliminated keyboard bounce. Of course, the 8032 has the unique CBM graphics characters and standard uppercase and lowercase letters.

The most dramatic improvement is in the video circuitry. Because the number of characters on the



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C. *CP/M Operating System*

III. SOFTWARE LIMITATIONS

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80-column screen is double that of the old 40-column display (expanding the video buffer to 2K bytes), the time needed to perform screen-oriented functions (clearing the screen, scrolling, etc.) would be increased. However, the display is now controlled by a 6845 integrated circuit that frees the microprocessor from having to perform display functions. It also provides extra spacing between lines of text. Descenders on one line no longer touch the ascenders of the line below. By changing to the graphic mode, lowercase and uppercase characters are replaced by uppercase and graphics characters, respectively, and the extra spacing between lines is removed.

Turning on the system or moving the cursor past the seventy-fifth column rings the system's bell. The speaker (actually a piezoelectric transducer) is connected to the CB2 line of the parallel port. Since this is the same line often used to create sound effects, these sounds can now be heard through the bell without an audio amplifier. The bell also rings when the ASCII bell code is printed.

At a Glance

Name
CBM 8032 computer system

Manufacturer
Commodore Business Machines
Computer Systems Division
The Meadows
487 Devon Park Dr.
Wayne, PA 19087
(215) 687-9750

Price
$2829.95 (suggested retail) including all required cables

Dimensions
Computer: 35.5 by 41.5 by 46.5 cm, 22.5 kg (14 by 16.5 by 18.5 inches, 50 lbs)
Disk drive: 16.5 by 38 by 36 cm, 12.5 kg (6.5 by 15 by 14.35 inches, 28 lbs)

Description
CBM 8032 computer: 6502 MOS Technology microprocessor, 73-key business-style keyboard, 12-inch green-phosphor display (80 characters by 25 lines, 2000 characters, 8 by 8 dot-matrix characters), IEEE-488 bus, 8-bit bidirectional parallel port, and two Commodore cassette ports included. 3-MHz system clock. 32K bytes (1K used for operating system overhead) plus 2K-byte screen buffer
4040 dual disk drive: Shugart 5¼-inch floppy-disk drives, single-sided, single-density, 174,848 bytes unformatted, 168,656 bytes formatted, 144 file entries per disk
Controller: 6504 microprocessor
Interface: 6502 microprocessor
Disk buffer: 4K bytes
CBM operating system included with 8032 computer: Microsoft BASIC, screen editor, and built-in IEEE-488 and disk commands (18K ROM)
Disk operating system included with 4040 disk drive: Program load and save; sequential; User, Relative, and Program files; file utilities (Copy, Rename, Scratch, Duplicate, New disk); Disk Directory; and Error Recovery

Software
Business software available (also see the Commodore Software Encyclopedia): Wordpro 4 Plus (word processing—Professional Software Inc.), Visicalc (electronic blackboard—Visicorp), The Manager (database—Canadian Micro Distributors), BPI, and CMS accounting software

Audience
This system is well suited for use in a modern office environment, as well as educational institutions and other business applications

New Software

To accompany the hardware modifications, Commodore has updated the operating system to version 4.0 in a way that complements the DOS. It now includes a new screen-oriented text editor, commands to simplify disk operations, and better string handling. Because the major change in this operating system is the addition of disk commands, the new version of BASIC is known as Disk BASIC (see the text box "A Quick Reference"). Notice that the new commands only make it easier to perform disk functions—they do not add any new features. The system defaults to device number 8, drive 0 (if this default can be changed, it is not documented).

To make these features available on older 16K- and 32K-byte CBM computers (those using version 3.0 BASIC), Commodore has released a version 4.0 read-only memory (ROM) upgrade. This will give the user all the enhanced commands, but not an 80-column screen. One catch is that the RECORD command (for random-access disk files) can only be used with DOS 2.1 and a 4040 floppy-disk-drive subsystem.

The disk commands are not the only change to BASIC, however. One other improvement is the string handling. When a string variable is used in a BASIC program, the BASIC interpreter sets aside memory space. As the string is reused, BASIC abandons the space and finds a new place in memory for the string's contents. Eventually, when all the free memory is used, the interpreter must collect and reuse the abandoned memory.

Garbage collection, as it is called, is also done when the system is asked to count the free memory locations. While garbage collection is going on, the system will not respond to the user. It therefore appears "dead" until the collection is done. The new version of the software does garbage collection in much less time. A collection that formerly might have taken as long as 21 minutes now takes only 0.64 seconds.

Commodore has also added disk-status flags to the new software. These special variables, DS and DS$, contain the status of the last disk operation and disk error. Without these, it would be necessary for the user to write a three-line program to determine the nature of a disk error.

Three other improvements have been made:

- when sending data to a device via the IEEE-488 interface, the system will send only a carriage-return character; it will not be followed by a linefeed character
- it is now possible to append data to an existing disk file
- if the input string from a device is more than 80 characters long, the system will generate a trappable error with the message "?string too long error"

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This 80-character limitation becomes apparent during disk-file operations. Although a record written to disk can be as long as 254 characters, and a string can be as long as 255 characters, any record that is more than 80 characters long must be accessed one character at a time, using the GET# command.

Better Editor

Although the editor has been improved, its operation is still the same. To change a line in a program, merely move the cursor to where the corrections are to be made, make the corrections (insert, delete, etc.), and push Return. The corrected line is entered as if you had retyped the whole thing.

What makes the editor so easy to use are the keys designated to perform each of the cursor movements, insertions, and deletions. Whole sections of programs can be copied from one program to another by listing the lines to be transferred on the screen, calling in the new program (which clears out the old one), moving the cursor to the start of the lines to be transferred, and pressing return for every line. The cursor does not have to be moved over each line, nor even moved to the end of each line. It is as simple as that and saves a lot of typing.

Special characters have been added to the screen editor that perform functions by using the video controller. (I've found that the graphics characters can be accessed from the keyboard if the 2 key is hit while pressing both shift keys.) The screen can now be scrolled up or down just by printing a special character; whole lines can be inserted or deleted, a line can be cleared to its end from any position, or from its beginning to any position.

Two of the special characters define the upper-left and lower-right corners of a *scrolling window*—a portion of the screen in which the movement of the cursor is restricted to preset boundaries. For instance, if you wanted to simulate the older 40-column screen, you could set one special character at the top of the screen, indented 20 spaces; the second special character would be indented 60 spaces on the bottom line. The cursor movement would then be restricted to this area.

This is also useful for defining split screens to display information. The information will scroll in the window, leaving the rest of the screen untouched, no matter where on the screen the window is defined. Normally, when the computer is turned on, the entire screen is the scrolling window.

One problem occurs if tabs are used in the program. The tabs are always computed from column 1 regardless of the scrolling window. If the tab is before or beyond the scrolling window, the cursor will be placed on the nearest edge within the scrolling window. The window is cleared simply by printing the ASCII Home character or pressing the Home key twice. A complete list of special screen-

A Quick Reference

DOS 1.0 is the operating system of a 2040. DOS 2.1 is the operating system of a 4040. DOS 2.1 can read a DOS 1.0 disk and DOS 1.0 can read a DOS 2.1 disk; however, neither should write on a disk formatted by the other.

New Disk BASIC Commands	Operation	See Notes
DSAVE	*Saves current program in memory on disk*	*1*
DLOAD	*Loads specified program into memory*	
CATALOG	*Lists the programs stored on the disk*	
DIRECTORY	*Same as CATALOG*	
SCRATCH	*Scratches specified program from disk*	*1,2*
RENAME	*Renames a file on disk*	*1*
CONCAT	*Concatenates two files*	*1*
COPY	*Copies specified file on disk*	*3*
BACKUP	*Track-to-track duplication from one disk to another*	*1*
COLLECT	*Collects disk space from unclosed files and verifies disk*	*1*
HEADER	*Formats a new disk for file storage*	*2*
DOPEN	*Opens a disk data file*	*1*
DCLOSE	*Closes a disk data file*	*1*
APPEND	*Opens old disk file to append additional data*	*1*
RECORD	*Specifies what record in a file will be read or written*	*4*

Note 1: *These commands cannot be used with DOS 2.1 with a disk that has been formatted with DOS 1.0 because they perform write functions and cause the "72,cbm v2 dos error."*
Note 2: *These commands will ask, "ARE YOU SURE?" A response of "Y" or "YES" to this will then perform the desired function.*
Note 3: *COPY can copy all the files on one disk to another. Use COPY to convert DOS 1.0 disks to DOS 2.1.*
Note 4: *This command (as well as some versions of DOPEN and COPY) will not work with DOS 1.0.*

Continued on page 372

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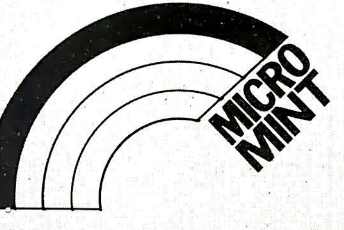
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As featured in Byte Magazine, July, August, 1981.

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Continued from page 370:

Screen-Control Function	Description	Decimal ASCII Code	Equivalent Control Character
BELL	*Sounds bell for ¼ second*	*7*	*g*
TEXT MODE	*Sets TEXT mode (uppercase/lowercase and extra spaces)*	*14*	*n*
SET TOP	*Sets top left of scrolling window at position*	*15*	*o*
DELETE LINE	*Deletes current line and scrolls screen up one line*	*21*	*u*
ERASE TO END	*Erases from current position to end of line*	*22*	*v*
SCROLL UP	*Scrolls screen up from bottom, top line lost*	*25*	*y*
GRAPHIC MODE	*Sets GRAPHIC mode (uppercase/graphic no space)*	*142*	*N*
SET BOTTOM	*Sets bottom right of scrolling window at position*	*143*	*O*
INSERT LINE	*Inserts a line at current position, scrolls down*	*149*	*U*
ERASE BEGINNING	*Erases from start of line to current position*	*150*	*V*
SCROLL DOWN	*Scrolls screen down from top, bottom line lost*	*153*	*Y*

Poking a 12 or 14 to location 59468 will not change the line spacing between lines. A function's code and inverse (i.e., DELETE LINE versus INSERT LINE or SCROLL UP versus SCROLL DOWN) are 128 apart (i.e., 21 (DELETE LINE) + 128 = 149 (INSERT LINE)

Further Notes (Some known bugs in the disk operating system)

1. *Sometimes when the pointer is moved from the middle of one record, it does not go to the beginning of the next record as it should. The RECORD command should be used to position the pointer before each I/O to the file.*
2. *The save and replace also found in DOS 1.0 has not been corrected.*
3. *When DS is less than 20 (but greater than 1), DS$ is blank.*
4. *Opening a data file without specifying the drive number causes a "FILE TYPE MISMATCH ERROR" by the DOS (this is taken care of in Disk BASIC).*
5. *The BLOCK-ALLOCATE command does not function properly.*
6. *The pattern matching with trailing '?'s does not match properly. "A???" will match the file "A", "AA", "AAA", or "AAAA", but not "AAAAA".*
7. *The D$ variable does not always match the ST variable after a disk operation.*
8. *SCRATCH will not remove a recently used data file because it finds that was used and believes that the file is still open.*
9. *The work-space buffers are not reclaimed when a disk file is not properly closed.*
10. *Scratching an open file will give the file a "DELETED" file type in the directory and garbles DS$.*
11. *Relative files cannot be copied with the COPY command. They must be rewritten or the disk they are on must be duplicated (backed up).*
12. *When drive 1 is automatically initialized, DS$ becomes incorrect.*

control characters can be found in the text box "A Quick Reference."

The screen editor also gives the space-bar and the cursor-control keys an automatic repeat and enables both the Repeat key and the Tab key. Holding down the Repeat key while pressing any other key will cause that key to repeat. The Tab key causes the cursor to move to the next tab stop. By pressing a Shift/Tab combination, a tab stop will be set (or cleared if one already exists) at the current cursor position. Since a tab stop can be set for each column, a total of 80 tabs can be set at any one time.

The ESC (Escape) key has also been given a function. One wants cursor controls to function while the program runs, but the same controls should be visible as special characters in a listing (it would be difficult to read the listing if the screen would clear each time a Clear Screen character was used). To avoid this problem, Commodore decided that if an odd number of quotes were typed on a line, the system would be in quote mode and a screen-control character would appear as a white-on-black character. The quote mode is also initiated when spaces have been inserted into a line with the Insert key. To end quote mode, you have to type another quote (unless it was initiated by the Insert key) or hit Return (and accept a line that should possibly not be accepted). By hitting the ESC key, you will escape from quote mode and the cursor keys will function normally.

The Run/Stop key has also been changed. In the old OS, it would load the next program from tape and run it. Now, it automatically loads and runs the first file from disk drive 0. This makes it easier for inexperienced operators to use software packages.

The Rest of the Story

Disk BASIC (OS version 4.0) was primarily designed to be used in conjunction with the new DOS 2.1. Though it can be used with the older DOS (version 1.0), the full potential of the system cannot be realized. Although access is the major and most important improvement to the DOS, Commodore has made other improvements.

The reliability of the disk drives has been improved by the removal of one sector (256 bytes) from each of the inner seven tracks on the disk. Because one of these sectors came from the directory track, there is now a maximum of 144 entries to the directory. This change also resulted in the loss of six data blocks from the disk. Because of this change, the disks made by the different DOSes *are not* compatible: but one can read disks made by the other (note that an 8050 can read only an 8050 disk). DOS 2.1 will generate a "CBM DOS V2" error if you try to write on a disk formatted by a version 1.0 system; however, if you write to a 2.1 formatted disk with DOS 1.0, the directory track will be disturbed and subsequent operations will cause disk errors.

Other changes to DOS 2.1 include an error counter in the BACKUP (a track-by-track duplication that destroys any data originally on the destination disk) command. To back up a disk now takes 2 minutes and 15 seconds instead of 6 to 7 minutes. Also, if the system encounters an error during a COLLECT (verify), the system will restore a bad Block Availability Map (which tells the DOS what blocks are free for use as storage). This was not available under DOS 1.0.

Another improvement is in the COPY command, which will now copy all the files on one disk to another. Trying to copy a file to disk where that file is already in use will produce the "FILE EXISTS" error message, and the COPY will be halted. When converting disks from DOS 1.0 to DOS 2.1, the COPY command is the one to use.

With random-access files, each record must be the same length, making it important to inform the DOS how large each record will be when the file is created. This is so that the DOS can compute where to position the disk's head for the next appropriate record. The maximum record length is 254 characters, with a maximum of 65,535 records in a file. (The disk would not be able to hold all 65,535 records if the record length was more than two characters.)

Part of the beauty of Commodore's system using intelligent peripheral devices is that they can be doing one thing while the microprocessor is doing another. For instance, when the disk drive sends out a record, it automatically does a "look-ahead" operation and gets the next record (this makes sequential operations faster) while the microprocessor busies itself with computations.

Software availability for any system is quite important. Usually, after the introduction of any new computer, it normally sits around for a time before any good software is available. For the CBM 8032, however, this is not the case. Any software written in standard BASIC or for Commodore computers should run on the 8032 without modification. It does, however, depend on how the program was written.

Because the 8032 uses the new version 4.0 OS (meaning different ROMs), any program that has machine-language calls to the operating system probably won't work without some modification. For instance, in the 8032, the interrupt vector points to a different location than in the older CBMs.

The other major difference that will cause a compatibility problem is the difference in the screen sizes. Programs (mostly games) that peek and poke at the screen buffer won't work due to the difference of line lengths on the screens and the additional 1000 bytes in the screen buffer of the 8032.

Since the 8032 is ostensibly a business computer, it is more important to have professional business software available than games. Fortunately, some very powerful business programs are on the market. One is Professional Software's Wordpro 4 Plus. This is possibly the most powerful word-processing software available for a stock microcomputer.

Another powerful software package available for the system is Visicalc. On the 80-column screen, you can lay out spreadsheets of all types (i.e., budgets, balance

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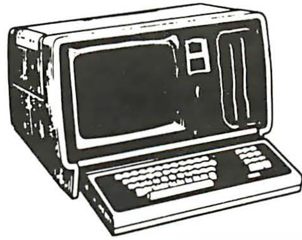
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sheets, etc.) to see how changing one element affects the rest.

Documentation

One area in which Commodore has made a remarkable improvement is documentation. In the past, documentation for Commodore computers has been quite poor, lacking both in content and approach. The 8032 comes with a *User's Reference Manual* that explains in a clear, concise manner the capabilities of the system and the entire command set. The command set is presented in a form used by other technical manuals showing the command format and syntax, in which version of Commodore BASIC it can be used, its purpose, remarks about the command, and detailed examples. The manual included with the 4040 explains the operation of the disk and the disk organization, as well as how to use the various disk commands.

I believe, however, that some documentation is lacking. From past experience, I know that a command can be abbreviated to the first few letters (i.e., goto = gO, gosub = goS, print# = pR, etc.). This time-saver is not mentioned in any of the manuals. The screen-control characters and the use of the screen editor (one of the nicer programming features on the system) are also completely missing from the documentation.

In the *User's Guide* is a system memory map by 1K-byte blocks. Included in that manual's appendix is a list of more than 20 system calls, plus the missing machine code needed to perform the listed function. All these system calls are common to all versions of Commodore's operating system. This is quite helpful for those who wish to do machine-language programming; however, Commodore omits the zero-page memory map, one of the most important memory maps for a 6502-based machine. My interpretation is that Commodore wants other people to write software for its machines that is independent of the model it was written on.

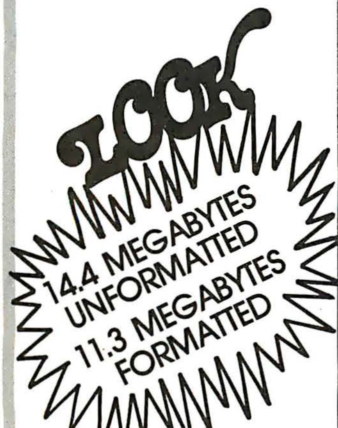
The upgrade ROM for Model 2001 computers will give you all the features and improvements of Disk BASIC, without an 80-column screen. Though the new operating system uses an additional ROM, helpful commands such as TRACE and RENUMBER were not included. (The request for "Programmer's Aid" routines has been answered by Power, a 4K-byte ROM from Professional Software Inc., 51 Fremont St., Needham, MA 02194.) Likewise, Commodore is offering an upgrade for the 2040 disk drive that makes it a 4040. This set of three ROMs and one controller will give an old 2040 random-access capability and increased reliability. Remember that if you upgrade to a 4040, your 2040 disks must be converted to the new DOS 2.1 format *before* you can write on them.

Conclusions

The CBM 8032 computer and 4040 disk drive form a good business system for the small to medium-size business. The lack of a marketing strategy by Commodore, as well as its past nonchalant attitude toward the encouragement and development of good software, has hurt its credibility, especially in comparison to the other systems on the market.

The available business software, Wordpro and Visicalc, make excellent use of the capabilities of the CBM 8032 and coincide with the environment in which it is best suited. The recognition of the companies who market these types of programs will keep this computer in a business atmosphere.

With an increasing number of competitive machines being brought to the marketplace, Commodore appears to be now providing better support and documentation on its systems. The documentation included with the CBM 8032 and the 4040 disk drive has improved over the documentation provided with past Commodore computer systems. ■







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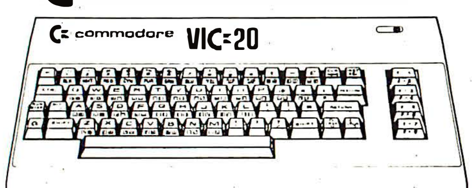
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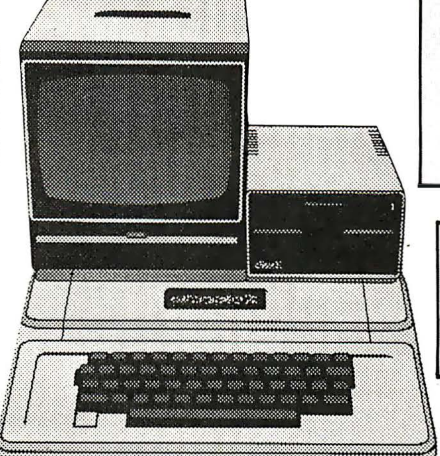
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Let the MC68701 Program Itself

Arnold J. Morales and David Ruhberg
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The Motorola MC68701 is an enhanced version of the MC6801 microprocessor. One of its chief features is the ability to program itself. The processing unit controls all movement of data into an on-chip EPROM (erasable programmable read-only memory). It controls programming power (V_{pp}) to the EPROM during programming, requiring only a few external devices to accomplish this.

On-chip resources of the MC68701 include a 2K-byte EPROM, a three-function timer, a serial-communication interface, up to 29 parallel I/O (input/output) lines, 128 bytes of RAM (random-access read/write memory), and an oscillator. These items provide a great deal of power and flexibility in a small package that's easy to use and design with.

In this article, we will explore how the MC68701 programs itself. We'll also discuss a fully tested MC68701 programmer, including software and a hardware design.

On-Chip EPROM

A dual-purpose MC68701 pin, $\overline{\text{RESET}}/V_{pp}$, is used both to reset the processor and to power the EPROM. This pin is normally +5 volts (V) during nonprogramming operation. It must be raised to V_{pp} (21 V ± 1 V) during programming of the EPROM. However, the processor will operate normally with V_{pp} applied at all times.

The MC68701 EPROM is controlled by two bits in the RAM/EPROM control register (see figure 1). Bit 0 of the register is called the programming latch control (PLC) and is used to control an address latch used during programming of the EPROM. Bit 1 of the register is called the programming power control (PPC) and is used to control V_{pp} to the EPROM during programming.

MC68701 RAM/EPROM CONTROL REGISTER

7	6	5	4	3	2	1	0
STBY PWR	RAME	X	X	X	X	PPC	PLC

Figure 1: *The RAM/EPROM control register. See the text for details of its operation.*

When PLC is set, the latch is transparent. When PLC is clear, the address latch is enabled and latches each EPROM address asserted by the processor. PLC should be set during normal nonprogramming processor operation; it should be cleared only to program the EPROM. This bit is set at RESET and can be cleared only in Mode 0 (more about modes later).

When PPC is set, V_{pp} is not applied to the EPROM; when PPC is clear, V_{pp} is applied to the EPROM. PPC should be set during normal nonprogramming operation; it should be cleared only to program the EPROM. This bit is set at $\overline{\text{RESET}}$ and whenever the PLC bit is set, and can be cleared only in Mode 0 with the PLC bit clear.

The MC68701 is programmed in Mode 0 only. In this mode, all the interrupt vectors and reset vectors are in the locations BFF0 to BFFF hexadecimal, and the on-chip EPROM is at locations F800 to FFFF hexadecimal. The

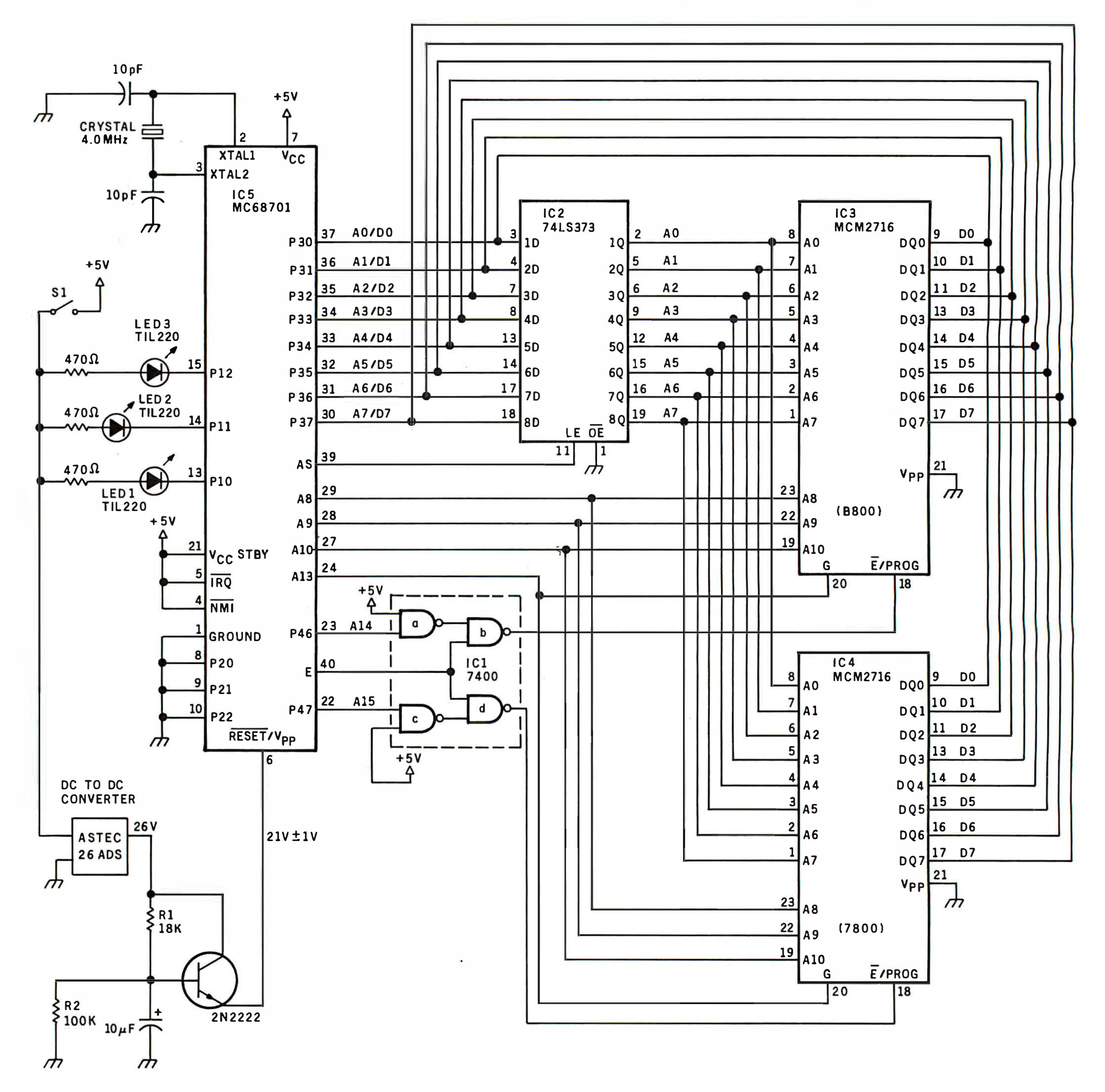


Figure 2: *Programmer for the MC68701. The simplicity of this inexpensive circuit means easy construction and use. In combination with the software provided in listing 1, LEDs in the programmer can indicate that the EPROM is initially erased and that the newly stored data pass or fail a verification test.*

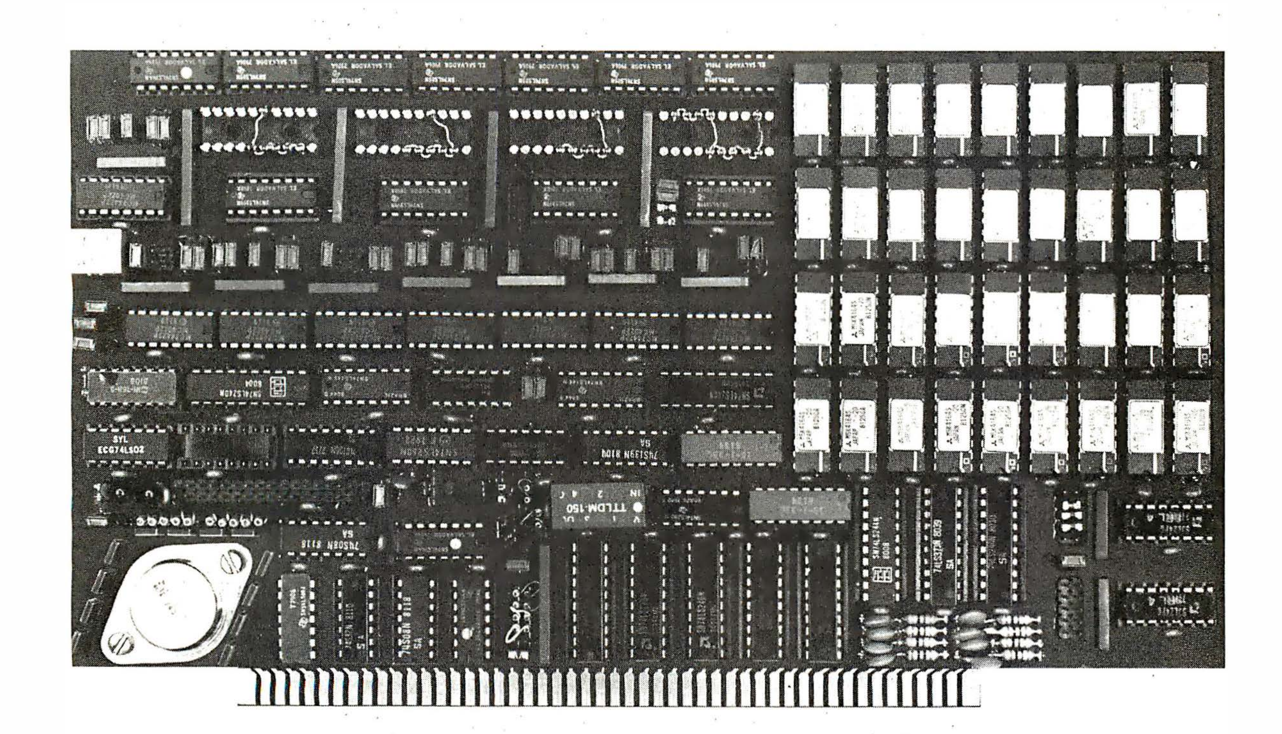
reset vectors should direct the processor to what is essentially a bootstrap-loading program that will fetch data sequentially from memory or a peripheral controller and "burn" each byte into the EPROM. Once V_{pp} is applied to the $\overline{\text{RESET}}/V_{pp}$ pin, each data byte is programmed into the onboard EPROM as follows:

1. Clear the PLC bit and set the PPC bit. This enables the EPROM address latch and inhibits V_{pp} to the EPROM.
2. Write data to the EPROM location to be programmed. Both the data and address will be captured by internal latches.
3. Clear the PPC bit for 50 milliseconds (ms). This controls programming power to the EPROM, allowing the data byte to be burned in.

These steps are repeated until all bytes have been programmed.

An MC68701 Programmer

Fully assembled and tested modules designed to program the MC68701 are available through Motorola distributors. Some users, however, may require custom programming boards designed to meet specific needs.



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The programmer described in this article (see figure 2) is designed for simplicity, low cost, and ease of use. The hardware and associated software verify that an inserted MC68701 is initially fully erased, do the programming, and verify the "entered" code. The user only applies power and monitors three light-emitting diodes (LEDs) that indicate EPROM status. The programmer enters the entire 2K-byte content of EPROM IC4 into the MC68701 EPROM. The system can be modified to, for instance, provide more detailed failure information or to program only a portion of the EPROM.

Using the Programmer

The user needs no knowledge of MC68701 operation and very little knowledge of electronics in order to use the programmer. Four steps are required:

1. Insert the EPROM containing the code to be programmed into the MC68701 into the socket at IC4.
2. Insert the MC68701 into the socket.
3. Apply power.
4. Monitor LEDs.

Within a few seconds after power is applied, LED 1 should light, indicating that the MC68701 EPROM is fully erased. Approximately 105 seconds after power is applied, LED 2 should light, indicating that the EPROM has been programmed and its contents verified. At this time, power can be removed from the system, and another MC68701 can be programmed.

LED 3 will light to indicate either a not fully erased MC68701 EPROM when power is initially applied, or failure to verify after attempted programming. If LED 3 lights and LED 1 is not lit, the MC68701 was not fully erased when inserted into the board. If this occurs, no attempt is made to program the EPROM. If LED 3 lights while LED 1 is lit, the EPROM's contents did not verify after attempted programming.

The LEDs should be color-coded to give readily recognized *pass* and *fail* indication. A good color scheme is amber for LED 1 (erased), green for LED 2 (pass), and red for LED 3 (fail). Zero insertion force sockets should be used for the MC68701 and EPROM.

Memory Map

The memory map, consisting of five special address spaces, is shown in figure 3. Four of the address spaces are fixed by the MC68701 during programming and cannot be relocated. These consist of an internal-register area (0000 to 001F hexadecimal), internal RAM (0080 to 00FF hexadecimal), external interrupt vectors (BFF0 to BFFF hexadecimal), and internal EPROM (F800 to FFFF hexadecimal).

A fifth address space is used for an MCM2716 that contains the code to be entered into the MC68701 on-chip EPROM. This MCM2716 has been arbitrarily placed at locations 7800 to 7FFF hexadecimal and can be relocated for custom programmer design.

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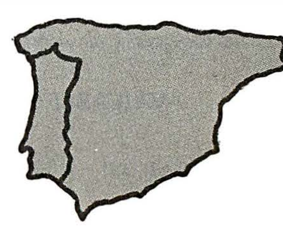
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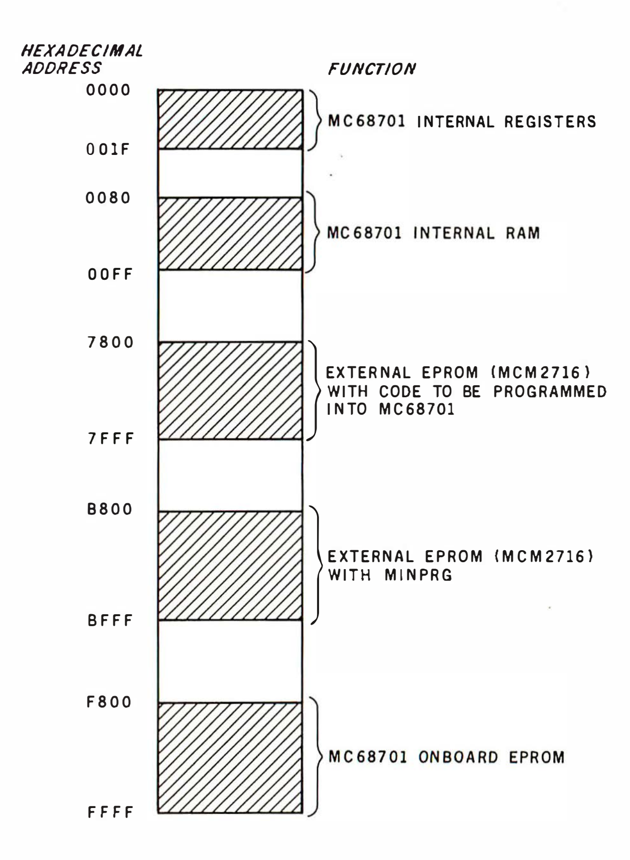


Figure 3: *Memory map of the MC68701 address space.*

For ease of decoding, an MCM2716 containing MINPRG, the programmer bootstrap program, is based at location B800 hexadecimal. The system RESET vectors are located at the top of the EPROM and decode at locations BFFE to BFFF hexadecimal.

Circuit Description

The MC68701 programmer consists of two MCM2716 EPROMs, a 74LS373 transparent latch, a 74LS00 NAND gate package, an MC68701 socket, and associated "glue," as shown in figure 2.

A 4-megahertz (MHz) crystal is used to yield 1-MHz operation. This clock frequency can be increased to accommodate higher-speed MC68701s, but changes in the operating frequency require changes in the MINPRG bootstrap software to ensure 50 ms programming time for each byte entered into the EPROM, or to minimize programming time.

This delay is governed by the value of WAIT in MINPRG and is indirectly related to the clock frequency. An increase in the clock frequency requires a proportional increase in the value of WAIT; a decrease of the clock frequency allows a proportional decrease in the value of WAIT.

The MC68701 can also be driven by an external transistor-transistor logic (TTL) clock at pin 3, with pin 2 grounded. If this clock option is used, the capacitors tied to pins 2 and 3, used to ensure stable crystal operation, are not required.

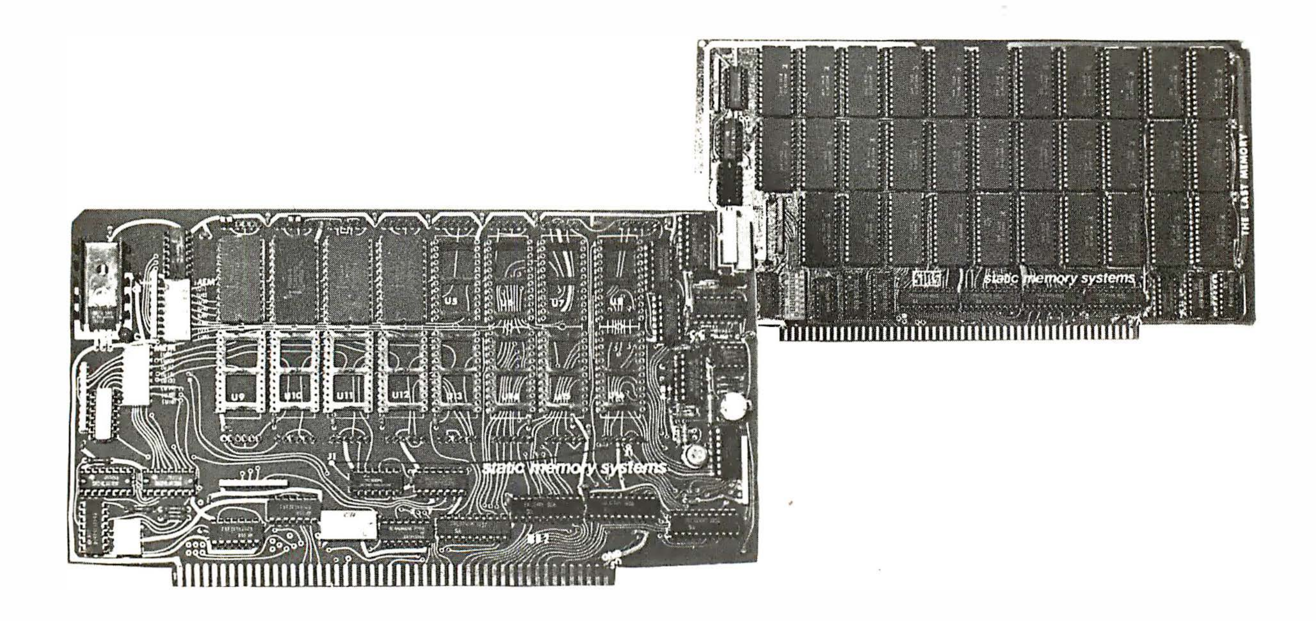
Pins 8, 9, and 10 are tied to ground to place the MC68701 into Mode 0 (programming mode) at RESET. IRQ (interrupt request) and NMI (nonmaskable interrupt) are tied high to eliminate external interrupts.

Three LEDs are tied to I/O pins 13, 14, and 15. They are used to indicate the state of the MC68701 EPROM during programming operations. High-current drivers force the pins low to light the LEDs.

The $\overline{\text{RESET}}/V_{pp}$ pin is driven by a transistor to assure adequate power to the pin during programming. The base of this transistor is controlled by an RC (resistor-capacitor) network that provides adequate delay between

Text continued on page 394
Listing 1 is on pages 388–392

TECHNOLOGY ADVANCES



THE LAST MEMORY™ is a high performance 64K memory module for 8 bit S100 systems. This board uses 16K byte-wide static RAM's which eliminate the timing and reliability problems associated with dynamic RAM boards. The 2K by 8 architecture of these RAM's allow high density and low power consumption, a characteristic not found in most static memories. This architecture also allows the use of 2716 type EPRPOM's in place of RAM IC's with no modification. As a result, this one board provides total system memory. **THE LAST MEMORY™** is available starting at less than $100.00

LASTING MEMORY™ is a combination EEPROM (Electrically Eraseable PROM)/EPROM/RAM memory module for 8 bit S100 systems. This board includes an onboard EEPROM programmer which programs and erases 2816/2815 type EEPROM's with normal memory write instructions - no special software is required. Erasing and writing may be performed one byte at a time - no need to start over to make simple changes. Programming may be performed in any socket - EEPROM's can be tested and used without moving them. EEPROM's, 2716 type EPROM's, or 16K byte-wide static RAM's may be located in any of the 16 memory sockets for a total of 32K bytes of memory. **LASTING MEMORY™** is available at $299.

The **VIB1™** is an intelligent I/O mapped CRT controller for use within S100 BUS (IEEE 696) systems. It incorporates all the video display capabilities of a stand-alone smart terminal. Some of its outstanding features include: 80 characters x 24 lines with an independant 25th line; full ASCII character set including control characters; graphics characters set; six visual attributes which can be used in combination; extensive screen editing and screen read capabilities. The **VIB1™** will be available in the 4th quarter 1982 at less than $300.

ideaLink™ is a high speed FSK modem which plugs into the S100 BUS (IEEE 696) and connects to a standard telephone in place of the handset. It is Bell 103/202 compatible offering both 300 Bps full duplex and 1200 Bps half duplex. All signal processing is performed digitally for long term reliability. **ideaLink™** will be available in the 4th quarter 1982 at less than $300.



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Circle 381 on inquiry card.

Listing 1: *MINPRG is the software that allows the MC68701 to program itself.*

```
                           *
                           *
                                 OPT    Z01,LLEM=80
                           *
                           *
                           *     THIS PROGRAM WILL CHECK, PROGRAM AND VERIFY
                           *               THE MC68701'S  EPROM
                           *
                           *
                           *          E Q U A T E S
                 0000    A P1DDR  EQU    $00       PORT 1 DATA DIR. REGISTER
                 0002    A P1DR   EQU    $02       PORT 1 DATA REGISTER
                 0008    A TCSR   EQU    $08       TIMER CONTROL/STAT REGISTER
                 0009    A TIMER  EQU    $09       COUNTER REGISTER
                 000B    A OUTCMP EQU    $0B       OUTPUT COMPARE REGISTER
                 0014    A EPMCNT EQU    $14       RAM/EROM CONTROL REGISTER
                           *
                           *          L O C A L   V A R I A B L E S
                           *
A 0080                           ORG    $80
A 0080           0002    A IMBEG  RMB    2         START OF MEMORY BLOCK
A 0082           0002    A IMEND  RMB    2         LAST BYTE OF MEMORY BLOCK
A 0084           0002    A PNTR   RMB    2         FIRST BYTE OF EPROM TO BE PGM'D
A 0086           0002    A WAIT   RMB    2         COUNTER VALUE
                           *
A B850                           ORG    $B850
A B850 8E 00FF   A START  LDS    #$FF      INITIALIZE STACK
A B853 86 07     A        LDAA   #$07      INIT. PORT 1
A B855 97 00     A        STAA   P1DDR     DDR
A B857 97 02     A        STAA   P1DR      DATA REGISTER (ALL LED'S OFF)
                           * *
A B859 CE F800   A        LDX    #$F800    CHECK IF EPROM ERASED
A B85C DF 84     A        STX    PNTR      INIT. PNTR WHILE CONVENIENT
A B85E C6 00     A        LDAB   #$00      GET READY FOR CMPR.
A B860 A6 00     A ERASE  LDAA   0,X       LOAD EPROM CONTENTS
A B862 11                 CBA              COMPARE TO ZERO
A B863 26 29 B88E         BNE    ERROR1    BRANCH IF NOT ZERO
A B865 8C FFFF   A        CPX    #$FFFF    CHECK IF DONE
A B868 27 03 B86D         BEQ    NEXT      IF SO BRANCH
A B86A 08                 INX              GO AGAIN
A B86B 20 F3 B860         BRA    ERASE
                           * *
A B86D 86 06     A NEXT   LDAA   #$06      TURN ON ERASED LED
A B86F 97 02     A        STAA   P1DR
                           * *
                           *    WAIT FOR VPP TO REACH 21V (3.5 SEC.)
                           *
A B871 DF 86     A        STX    WAIT
A B873 CE 0046   A        LDX    #$0046    GET READY FOR 70 TIMES THRU LOOP
A B876 09          STALL1 DEX
A B877 CC C350   A        LDD    #$C350    INIT. 50MS LOOP
A B87A D3 09     A        ADDD   TIMER     BUMP CURRENT VALUE
A B87C 7F 0008   A        CLR    TCSR      CLEAR OCF
A B87F DD 0B     A        STD    OUTCMP    SET OUTPUT COMPARE
A B881 86 40     A        LDAA   #$40      NOW WAIT FOR OCF
A B883 95 08     A STALL2 BITA   TCSR
A B885 27 FC B883         BEQ    STALL2    NOT YET
A B887 8C 0000   A        CPX    #$0000    70 TIMES YET?
```

Listing 1 continued on page 390

Listing 1 continued:

```
00059A B88A 26 EA B876          BNE    STALL1    NOPE
00060A B88C 20 06 B894          BRA    PGINT
00061                    * *
00062A B88E 86 83     A ERROR1  LDAA   #$83      LIGHT ERROR LED ONLY
00063A B890 97 02     A         STAA   P1DR
00064A B892 20 5D B8F1          BRA    SELF
00065                    * *
00066A B894 CE 7800   A PGINT   LDX    #$7800    INIT. IMBEG
00067A B897 DF 80     A         STX    IMBEG
00068A B899 CE 7FFF   A         LDX    #$7FFF    INIT. IMEND
00069A B89C DF 82     A         STX    IMEND
00070A B89E CE C350   A         LDX    #$C350    INIT. WAIT  (4.0 MHZ)
00071A B8A1 DF 86     A         STX    WAIT
00072                    *
00073                    *      THIS PART FROM 68701 DATA SHEET
00074                    *
00075A B8A3 DE 84     A EPROM   LDX    PNTR      SAVE CALLING ARGUMENT
00076A B8A5 3C                  PSHX             RESTORE WHEN DONE
00077A B8A6 DE 80     A         LDX    IMBEG     USE STACK
00078                    *
00079A B8A8 3C          EPROO2  PSHX             SAVE POINTER ON STACK
00080A B8A9 86 FE     A         LDAA   #$FE      REMOVE VPP, SET LATCH
00081A B8AB 97 14     A         STAA   EPMCNT    PPC=1,PLC=0
00082A B8AD A6 00     A         LDAA   0,X       MOVE DATA MEMORY-TO-LATCH
00083A B8AF DE 84     A         LDX    PNTR      GET WHERE TO PUT IT
00084A B8B1 A7 00     A         STAA   0,X       STASH AND LATCH
00085A B8B3 08                  INX              NEXT ADDR.
00086A B8B4 DF 84     A         STX    PNTR      ALL SET FOR NEXT
00087A B8B6 86 FC     A         LDAA   #$FC      ENABLE EPROM POWER (VPP)
00088A B8B8 97 14     A         STAA   EPMCNT    PPC=0,PLC=0
00089                    *
00090                    *       NOW WAIT 50 MSEC TIMEOUT USING COMPARE
00091                    *
00092A B8BA DC 86     A         LDD    WAIT      GET CYCLE COUNTER
00093A B8BC D3 09     A         ADDD   TIMER     BUMP CURRENT VALUE
00094A B8BE 7F 0008   A         CLR    TCSR      CLEAR OCF
00095A B8C1 DD 0B     A         STD    OUTCMP    SET OUTPUT COMPARE
00096A B8C3 86 40     A         LDAA   #$40      NOW WAIT FOR OCF
00097A B8C5 95 08     A EPROO4  BITA   TCSR
00098A B8C7 27 FC B8C5          BEQ    EPROO4    NOT YET
00099                    *
00100A B8C9 38                  PULX             SET UP FOR NEXT ONE
00101A B8CA 08                  INX              NEXT
00102A B8CB 9C 82     A         CPX    IMEND     MAYBE DONE
00103A B8CD 23 D9 B8A8          BLS    EPROO2    NOT YET
00104A B8CF 86 FF     A         LDAA   #$FF      REMOVE VPP, INHIBIT LATCH
00105A B8D1 97 14     A         STAA   EPMCNT    EPROM CAN NOW BE READ
00106A B8D3 38                  PULX             RESTORE PNTR
00107A B8D4 DF 84     A         STX    PNTR
00108                    * *
00109                    *        START NEW CODE
00110                    *
00111A B8D6 CE 7800   A         LDX    #$7800    SET UP POINTER
00112A B8D9 3C          VERF2   PSHX             SAVE POINTER ON STACK
00113A B8DA A6 00     A         LDAA   0,X       GET DESIRED DATA
00114A B8DC DE 84     A         LDX    PNTR      GET EPROM ADDR.
00115A B8DE E6 00     A         LDAB   0,X       GET DATA TO BE CHECKED
00116A B8E0 11                  CBA              CHECK IF SAME
```

Listing 1 continued on page 392

Collector Edition

BYTE COVERS

The Byte covers shown below are available as beautiful Collector Edition Prints. Each full color print is 11″ × 14″, including 1½″ border, and is part of an edition strictly limited to 500 prints. The artist, Robert Tinney, has personally inspected, signed and numbered each print. A Certificate of Authenticity accompanies each print guaranteeing its quality and limited number.

The price of a Collector Edition Byte Cover is $25, plus $3 per shipment for postage and handling ($8 for overseas airmail). Collector Prints 9, 10, 11 and 12 can be purchased as a set for $80, as can Prints 13, 14, 15 and 16.

Collector Edition Byte Covers are also available in the beautiful mat and frame shown above for $60 each (if Set 9-12 or Set 13-16 is ordered framed and matted, the price per set is $200). The mat is a neutral gray which blends with most decors, and the black 12″ × 16″ frame is trimmed in silver. The print is mounted under non-glare glass.

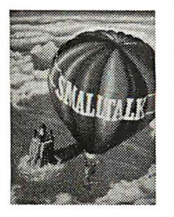
Framed and matted prints are shipped UPS—no delivery to P.O. boxes. Because of expense and breakage, no framed prints are shipped overseas. Please allow 4-6 weeks delivery for framed prints.

To order use the coupon below; Visa and Master Charge orders may call Toll Free.

Set 13-16, $80



FUTURE COMPUTERS
Print 13 - $25



SMALLTALK
Print 14 - $25



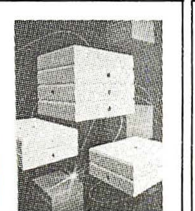
SOFTWARE
Print 15 - $25



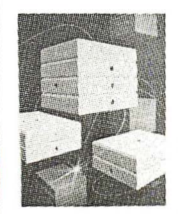
CHIP BUILDING
Print 16 - $25

Set 9-12, $80

SOFTWARE PIRACY
Print 9 - $25



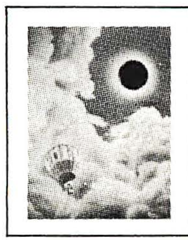
THE PROGRAMMING ROUTE
Print 10 - $25



FORTH
Print 11 - $25



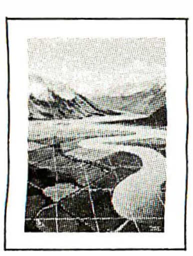
FUTURE PAST
Print 12 - $25



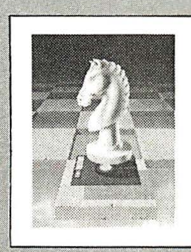
TOTAL ECLIPSE
Print 6 - $25



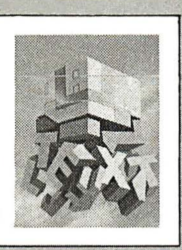
COMPUTER HARDWARE
Print 7 - $25



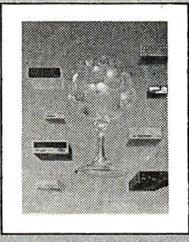
PERSPECTIVES
Print 8 - $25



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$7.95



THROUGH THE TRAP DOOR
Mar. 1979
$35.00



BREAKING THE SOUND BARRIER
Sept. 1977
$35.00

ALSO AVAILABLE are the prints shown at left. "Computer Chess" is an 18″ X 22″ full color poster.

"Through the Trap Door" and "Breaking the Sound Barrier" are limited editions of 750 prints each, signed and numbered by the artist. Each print is 18″ X 22″, and is accompanied by its own Certificate of Authenticity. **If both "Door" and "Barrier" are ordered, a special price of $55 applies.**

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Listing 1 continued:

```
00117A B8E1 26 10 B8F3        BNE    ERROR2   BRANCH IF ERROR(LIGHT LED)
00118A B8E3 08                INX             NEXT ADDR
00119A B8E4 DF 84     A       STX    PNTR     ALL SET FOR NEXT
00120A B8E6 38                PULX            SETUP FOR NEXT ONE
00121A B8E7 08                INX             NEXT
00122A B8E8 8C 8000   A       CPX    #$8000   MAYBE DONE
00123A B8EB 26 EC B8D9        BNE    VERF2    NOT YET
00124                    * *
00125A B8ED 86 84     A       LDAA   #$84
00126A B8EF 97 02     A       STAA   P1DR     LIGHT VERIFY LED
00127                    * *
00128A B8F1 20 FE B8F1 SELF   BRA    SELF     WAIT FOREVER
00129                    * *
00130A B8F3 86 82     A ERROR2 LDAA  #$82     LIGHT ERROR & ERASED LED'S
00131A B8F5 97 02     A       STAA   P1DR
00132A B8F7 20 F8 B8F1        BRA    SELF
00133                    * *
00134                    *     R E S T A R T   A N D   I N T R . V E C .
00135                    *
00136A BFF0                   ORG    $BFF0
00137A BFF0    B8F1   A       FDB    SELF
00138A BFF2    B8F1   A       FDB    SELF
00139A BFF4    B8F1   A       FDB    SELF
00140A BFF6    B8F1   A       FDB    SELF
00141A BFF8    B8F1   A       FDB    SELF
00142A BFFA    B8F1   A       FDB    SELF
00143A BFFC    B8F1   A       FDB    SELF
00144A BFFE    B850   A       FDB    START
00145                         END
TOTAL ERRORS 00000--00000
```

```
     0014 EPMCNT 00016*00081 00088 00105
     B8A3 EPROM  00075*
     B8A8 EPROO2 00079*00103
     B8C5 EPROO4 00097*00098
     B860 ERASE  00035*00041
     B88E ERROR1 00037 00062*
     B8F3 ERROR2 00117 00130*
     0080 IMBEG  00021*00067 00077
     0082 IMEND  00022*00069 00102
     B86D NEXT   00039 00043*
     000B OUTCMP 00015*00054 00095
     0000 P1DDR  00011*00029
     0002 P1DR   00012*00030 00044 00063 00126 00131
     B894 PGINT  00060 00066*
     0084 PNTR   00023*00033 00075 00083 00086 00107 00114 00119
     B8F1 SELF   00064 00128*00128 00132 00137 00138 00139 00140 00141 00142
                 00143
     B876 STALL1 00050*00059
     B883 STALL2 00056*00057
     B850 START  00027*00144
     0008 TCSR   00013*00053 00056 00094 00097
     0009 TIMER  00014*00052 00093
     B8D9 VERF2  00112*00123
     0086 WAIT   00024*00048 00071 00092
```

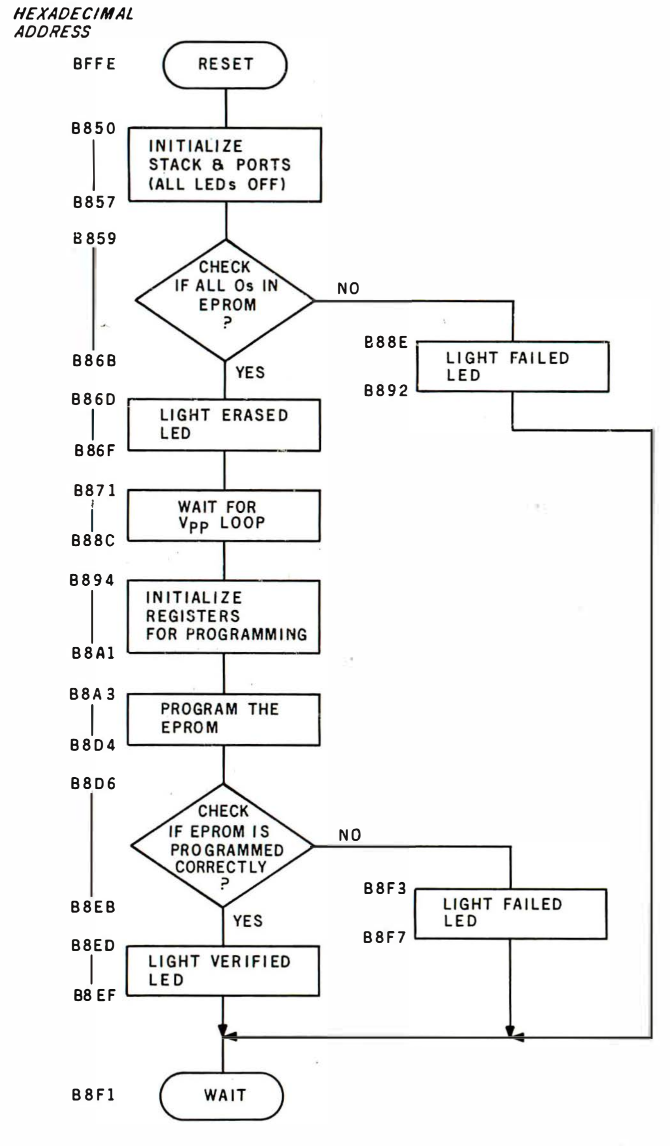


Figure 4: *Flowchart of the programmer software called MINPRG. The program is shown in listing 1.*

Text continued from page 386:

the application of V_{CC} and $\overline{\text{RESET}}$. During programming, 21 V ± 1 V (V_{pp}) must be applied to the $\overline{\text{RESET}}/V_{pp}$ pin. A 5- to 26-V voltage converter is used to eliminate the need for two power supplies. R1 and R2 form a voltage divider that provides a proper voltage level to the $\overline{\text{RESET}}/V_{pp}$ pin. R2 also serves to discharge C1 during power-down.

A 74LS373 transparent latch is used to demultiplex port 3, which is used both as a lower address port (signals A0 through A7) and as a data port. An address strobe (AS) from the MC68701 is tied to latch enable (LE) of the 74LS373 to latch the lower-order address at the proper time each bus cycle. Once the lower address is latched, the port is used for data transfer.

Four NAND gates are used for address decoding of the two external EPROMs. Each EPROM is selected with high A13 to ensure deselection during access of MC68701 internal RAM and internal registers. EPROM IC3 drivers are enabled with low A14 and high E; EPROM IC4 drivers are enabled with low A15 and high E. Controlling with E ensures that drivers are in the high-impedance state during E low, eliminating driver contention on the multiplexed lower-address/data bus. Controlling the drivers with low A14/A15 assures separation between the off-chip and on-chip EPROM address spaces. EPROM IC3, containing MINPRG, is selected at locations B800 to BFFF hexadecimal; EPROM IC4, containing the program to be entered into the MC68701 EPROM, is selected at locations 7800 to 7FFF hexadecimal. Incomplete address decoding is used for IC3 and IC4 to minimize the number of devices used in the system, allowing their selection in several address spaces. Care must be taken when writing software for the system to ensure that only one device is accessed at any time.

Note that only Motorola MCM2716 EPROMs allow an optional active high chip select (pin 20) by tying V_{pp} (pin 21) low during reads. If non-Motorola 2716 EPROMs are used, V_{pp} must be tied high and A13 must be inverted to the active low chip selects.

Program Description

The programmer uses a bootstrap program, MINPRG, to control programming of the MC68701 EPROM. The program performs the following functions:

1. Initialize the MC68701.
2. Check that the EPROM is erased.
3. Program the EPROM.
4. Verify the program.
5. Stop.

MINPRG also controls three LEDs that indicate MC68701 EPROM status during programmer operation. A detailed flowchart of MINPRG is shown in figure 4; a complete listing is shown in listing 1 on page 388.

Program Modifications and Considerations

Additions and modifications to this code can be made easily by inserting routines between the basic blocks on the flowchart. For convenience, the start and stop addresses of each block are located directly to the left of each block.

Parameters IMBEG, IMEND, PNTR, and WAIT, stored in RAM locations 80 to 87 hexadecimal, determine the size of the data block to be programmed into the MC68701, the first MC68701 EPROM location to be programmed, and the time period each byte will be burned into the EPROM. These parameters can be changed to allow programming of selected EPROM locations and to allow changes in operating frequency. These parameters, once selected, should remain constant throughout the entire program.

A modification to MINPRG that should be considered is verification of the EPROM if the EPROM is not initially erased, rather than to simply light LED 1 and wait. This change would allow verification of MC68701 EPROMs that have already been programmed and used.■


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Birth of a legend.



Epson.

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For instance, they've got a few extra type styles. Sixty-six, to be exact, including italics, a handy subscript and superscript for scientific notation, and enough international symbols to print most Western languages.

What's more, on the new-generation MX-80, MX-80 F/T and MX-100, you get GRAFTRAX-Plus dot addressable graphics. Standard. So now you can have precision to rival plotters in a reliable Epson printer. Not to mention true backspace, software printer reset, and programmable form length, horizontal tab and right margin.

All in all, they've got the features that make them destined for stardom. But the best part is that beneath this software bonanza beats the

Uh...three legends.

heart of an Epson. So you still get a bidirectional, logical seeking, disposable print head, crisp, clean, correspondence quality printing, and the kind of reliability that has made Epson the best-selling printers in the world.

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Bidirectional printing	X	X	X	X	X	X
Logical seeking function	X	X	X	X	X	X
Disposable print head	X	X	X	X	X	X
Speed: 80 CPS	X	X	X	X	X	X
Matrix: 9 x 9	X	X	X	X	X	X
Selectable paper feed			X		X	X
PAPER HANDLING FUNCTIONS						
Line spacing to n/216		X		X	X	X
Programmable form length	X	X	X	X	X	X
Programmable horizontal tabs	X	X	X	X	X	X
Skip over perforation			X	X	X	X
PRINT MODES AND CHARACTER FONTS						
96 ASCII characters	X	X	X	X	X	X
Italics character font		X		X	X	X
Special international symbols				X	X	X
Normal, Emphasized, Double-Strike and Double/Emphasized print modes	X	X	X	X	X	X
Subscript/Superscript print mode				X	X	X
Underline mode				X	X	X
10 CPI	X	X	X	X	X	X
5 CPI	X	X	X	X	X	X
17.16 CPI	X	X	X	X	X	X
8.58 CPI	X	X	X	X	X	X
DOT GRAPHICS MODE						
Line drawing graphics				X	X	X
Bit image 60 D.P.I.		X	X	X	X	X
Bit image 120 D.P.I.		X	X	X	X	X
CONTROL FUNCTIONS						
Software printer reset		X		X	X	X
Adjustable right margin			X	X	X	X
True back space		X		X	X	X
INTERFACES						
Standard — Centronics-style 8-bit parallel	X	X	X	X	X	X
Optional — RS-232C current loop w/2K buffer	X	X	X	X	X	X
RS-232C x-on/x-off w/2K buffer	X	X	X	X	X	X
IEEE-488	X	X	X	X	X	X

*Tandy TRS-80 block graphics only available with GRAFTRAX 80.

ABCDEFGHIJKLMN abcdefghijklmn *ABCDEFGHIJKLMN abcdefghijklmn* Ø1234
ABCDEFGHIJKLMN abcdefghijklmn *ABCDEFGHIJKLMN abcdefghijklmn* Ø1234
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ABCDEFGHIJKLMNOPQRSTUVWX abcdefghijklmnopqrstuvwx *ABCDEFGHIJKLMNOPQRSTUVWX abcdefghijklmnopqrstuvwx* Ø1234567
ABCDEF abcdef *ABCDEF abcdef* Ø123456
ABCDEFGHIJKLMN abcdefghijklmn *ABCDEFGHIJKLMN abcdefghijklmn* Ø1234
ABCDEFGHIJKLMNOPQRSTUVWX abcdefghijklmnopqrstuvwx *ABCDEFGHIJKLMNOPQRSTUVWX abcdefghijklmnopqrstuvwx* Ø1234567

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The Heath/Zenith Model 47 Dual Floppy-Disk System

Christopher O. Kern
201 I St. SW, Apt 839
Washington, DC 20024

The H-47-BA (also called the Z-47-BA) is a dual-drive 8-inch floppy-disk subsystem for the Heath H-8 and H-89 (or Z-89) computers (the "H" models are provided in kit form by Heath Company; "Z" designates assembled products sold by the parent Zenith Corporation). The H-/Z-47 (the BA suffix is dropped throughout) provides approximately 2 megabytes of online storage, which should be adequate for most hobby and many small-business purposes. Equally important, it provides standard IBM soft-sectored floppy-disk compatibility for the Heath/Zenith product line, which substantially increases the amount of software that is available.

Under CP/M, a formatted double-sided, double-density disk (with twenty-six 256-byte physical sectors per track) has 980K bytes of usable storage capacity. The comparable figure for HDOS is 999K bytes. The difference is the result of how the two operating systems organize their disk directories and other supporting software. Heath's implementation of CP/M also supports an "extended double-density" format where each track is divided into eight sectors of 1024 bytes each. With extended double density, the usable capacity of a double-sided disk is 1208K bytes. This format is not in general use and disks using it normally will not be readable by other CP/M-based computer systems.

Disk deblocking under CP/M (transforming the 256- and 1024-byte sectors that are physically present on the disk into the 128-byte logical sector that CP/M expects) is invisible to the user. One of the advantages of the denser recording formats is that multiple logical read-sector operations can be performed by a single *physical* disk access. This speeds up disk I/O (input/output) because it is faster to withdraw data from a buffer in semiconductor memory than to read it from the disk. Both Heath-supplied operating systems identify the number of sides and the density of the disk at the time that it is logged in. Densities can be mixed, and a single-sided disk can be used in one drive while a

At a Glance

Name
H-47-BA, Z-47-BA

Type
Dual-drive 8-inch floppy-disk subsystem

Capacity
Up to 2.4 megabytes (1.2 megabytes/drive) depending on operating system and disk density

Manufacturer
Heath Company (H-47 kit)
Zenith Data Systems (Z-47-BA assembled unit)
Benton Harbor, MI 49022
(616) 982-3200

Price
$2595, kit; $3500, assembled

Computer
Heath H-8 (requires interface card, kit only, $350; H-8s equipped with 8080A processor require "extended configuration" option, $65); Heath H-89 and Zenith Z-89 (require Z-89-47 interface card, assembled only, $195; older units may need other minor hardware modifications)

Audience
Advanced hobbyists, business users of Heath computers who require large-capacity floppy-disk storage

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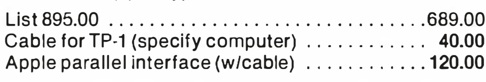
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	LA120 DECwriter III RO	2,095	200	112	75
	LA12A Portable DECwriter	2,950	280	155	106
	VT100 CRT DECscope	1,695	162	90	61
	VT101 CRT DECscope	1,195	115	67	43
	VT125 CRT Graphics	3,295	315	185	119
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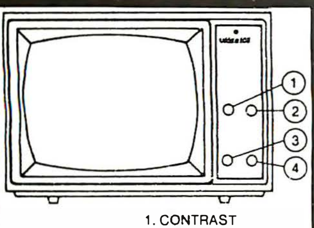
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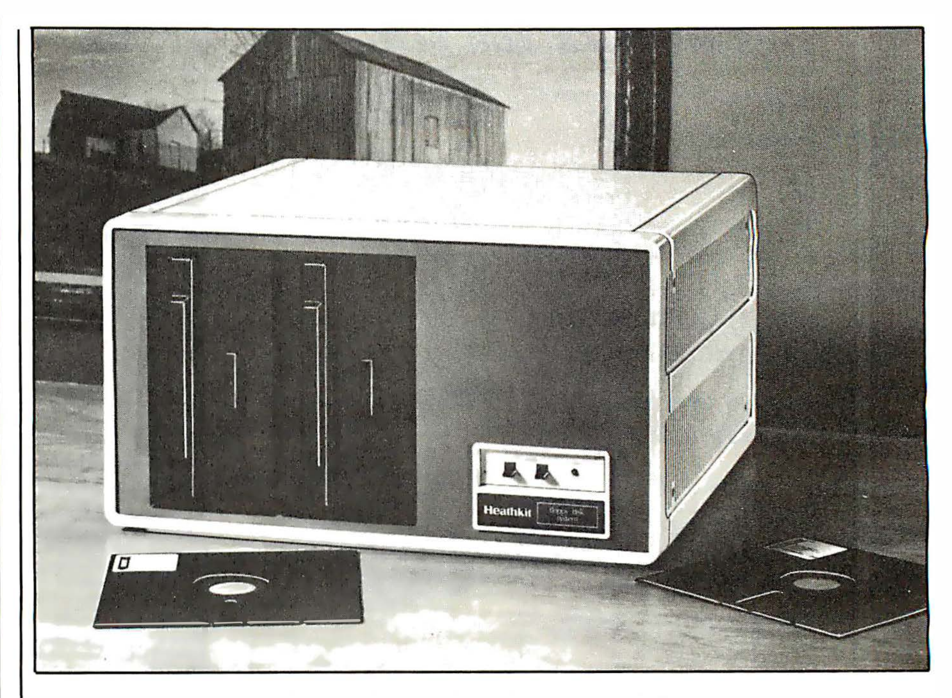


Photo 1: *Front view of the Heath/Zenith 47 dual floppy-disk system.*

double-sided disk is in the other.

Previous Heath disk systems, based on single-density 5¼-inch floppy-disk drives, provided a maximum of roughly 300K bytes of online storage, so the 2-megabyte H-/Z-47 represents a major increase in system capacity. Up to three 5¼-inch drives can still be used in addition to the H-/Z-47 with either the H-8 or H-/Z-89 computers.

Speed of Disk I/O

An incidental benefit of adding 8-inch drives to an existing 5¼-inch system is an increase in disk-access speed, especially when using extended double density under CP/M. According to Heath's specifications, the average time required to access a particular sector is about 15 percent faster on the H-/Z-47 than on Heath's 5¼-inch drives (191 ms compared with 225 ms). My rudimentary tests confirmed that most disk-bound programs run about 15 percent faster.

The most noticeable speed-up is in the time required to initiate a CP/M transient program or open a data file. This is particularly apparent when lengthy "batch" jobs are being run under CP/M's SUBMIT facility. An experimental Unix-like disk operating system I have been using, which must often read down a hierarchy of file directories, was rather laggardly with 5¼-inch drives. It perked up considerably when run on the H-/Z-47.

Operating Requirements

Interface cards for the H-8 and H-/Z-89 computers are sold separately. These provide the control logic for disk input and output, as well as the buffer memory required to store data that has been read from or written to the disk. The interface board for the H-8 also provides two programmable RS-232C serial channels. If a system has only serial peripheral devices (e.g., a terminal and a printer), this can free an extra card position on the H-8 bus.

The H-/Z-47 is large (19 by 18½ by 10⅜ inches) and fairly heavy (65 pounds). The twin cooling fans in the back of the unit are relatively quiet and they provide excellent, filtered, positive ventilation (this should keep dust away from the surfaces of the disks). The noise level of the active drives is about average, *but I* don't think the H-/Z-47 would be intrusive in the average office.

The H-/Z-47 carries an FCC-required warning label to the effect that its operation in residential areas may cause RFI and TVI (radio and television interference) and that the user is responsible for ensuring that this doesn't happen. But there was no sign of TVI when I operated the unit

within a few feet of a portable television set that has proved sensitive to interference from other sources.

No preventive maintenance is required. The drive manufacturer (Remex) does not even recommend cleaning the read/write head. Repair service is available at the various Heathkit Electronic Centers around the country and from the factory in Benton Harbor, Michigan. In my experience with previous Heath products, repairs are invariably done correctly and usually within a week. Heath also maintains a special technical-service telephone number for those who want to troubleshoot Heath equipment themselves. I have found this fairly helpful on occasion, although there are obvious limits to how much can be accomplished on the phone.

Construction

Heath is one among the dwindling number of manufacturers that still supplies computer products in kit form. I have been building Heathkits off and on for the better part of 20 years, and construction of the H-47 was more reminiscent of some of those earlier projects than, say, of building my H-8 computer. Most of the required wiring is point-to-point. The two disk drives, along with their associated electronics, come preassembled. There are only two small printed-circuit boards that must be prepared. One contains two front-panel switches that make it possible to write-protect a disk electronically (as well as by the usual method of removing the adhesive write-enable tab). The other circuit board, on the rear panel, provides various connectors for the wiring harnesses.

The rest of the job falls into two main categories: wiring the power supply and assembling the sheet-metal parts that form the chassis. Most of the power-supply components are easy to get to, although there are a few places where wires are packed closely enough to require care in maneuvering a hot soldering iron. The chassis assembly is considerably more complex than that of other Heath products I have built, and it gets fairly involved as more and more parts are added. There were a couple of times when a second pair of hands would have helped. Despite the relatively large number of sheet-metal components, everything fits together with gratifying precision and the finished product is very solid.

Heath's assembly instructions have long been the standard against which others are judged, and the 65-page manual for the H-/Z-47 (supplemented by a schematic diagram and a 30-page booklet of large illustrations) fully lived up to my expectations. I found only one minor error—the picture of the AC line filter in the assembly manual didn't match the part that was actually supplied—but it was obvious from other illustrations how the part was intended to fit. From start to finish, the unit required 9½ hours of construction time, and it worked perfectly the moment it was powered up.

The H-8 and H-/Z-89 interface cards, like the controller electronics on the two disk drives, are supplied prewired. Apparently there is little savings to be had in providing printed circuits in kit form now that auto-

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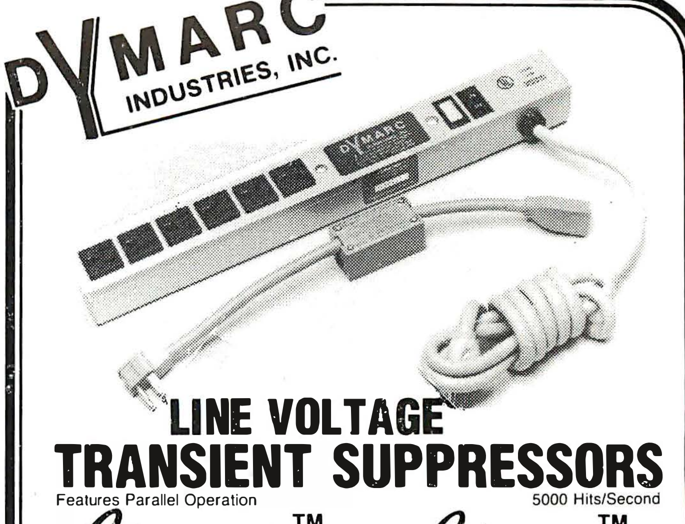
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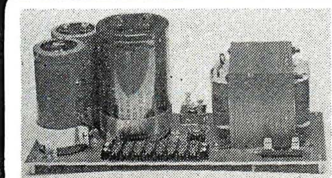
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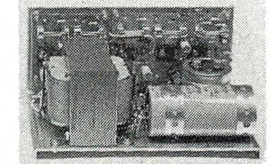
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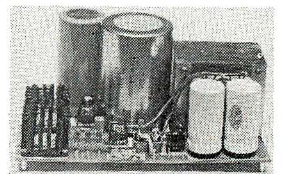
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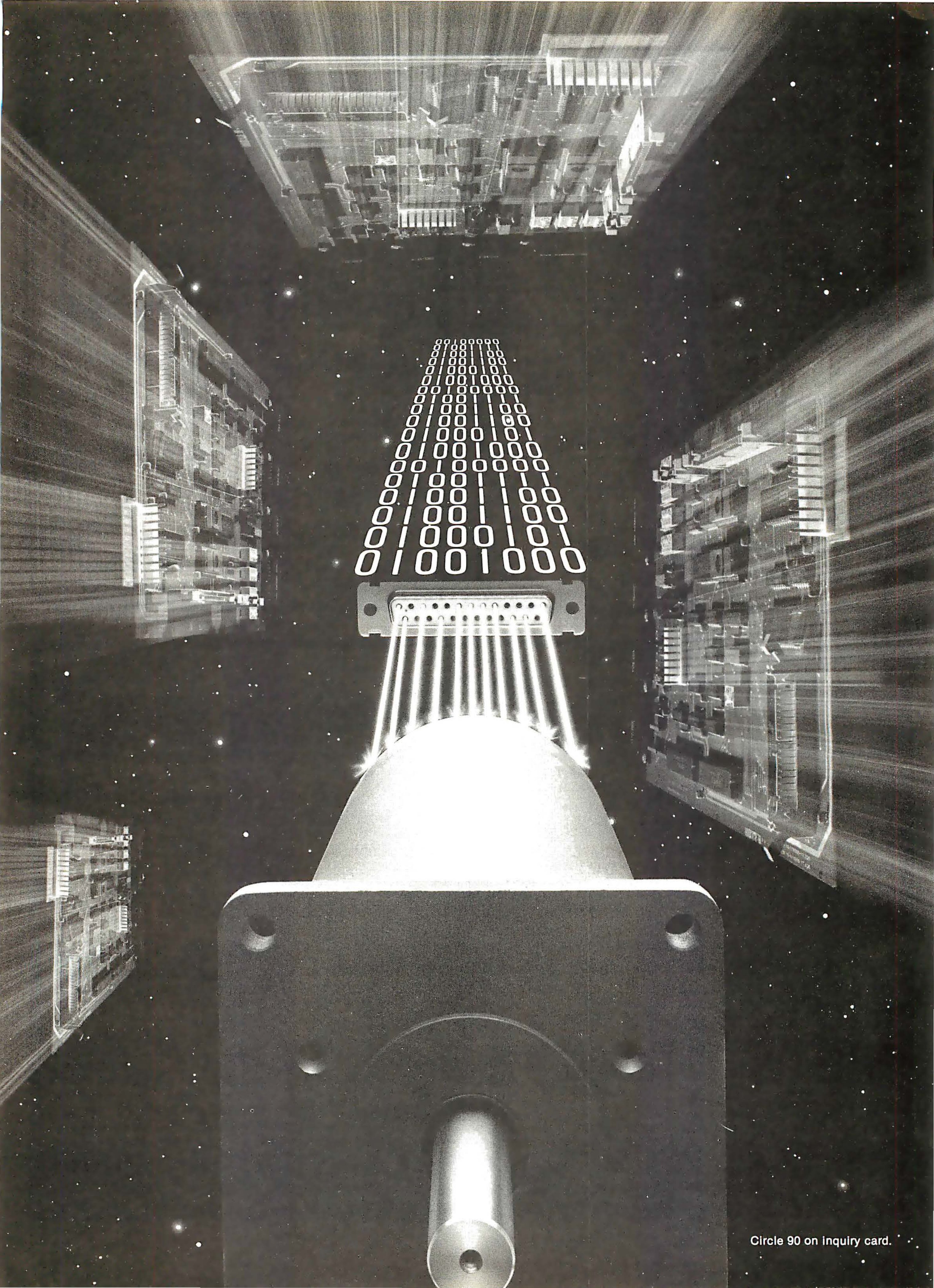
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mated assembly equipment is available to manufacturers. I don't mourn the loss. Stuffing printed-circuit boards is boring and it demands intense attention to soldering technique because of the high speeds involved in digital electronics and the high component density of modern boards.

The Heath operating system, HDOS, includes a disk-drive test program along with a number of other useful diagnostics. The program—which runs for a full hour on an 8-inch double-sided disk, reading and writing random as well as sequential disk sectors—provides a fairly stringent test of the drive's ability to stand up to heavy usage. Both H-/Z-47 drives performed perfectly, with no soft (recoverable) or hard (nonrecoverable) errors. Even after two hours of strenuous operation, the unit did not heat up noticeably.

Use with Existing Systems

The H-8 computer requires a minor hardware modification (Heath's "extended configuration" card) when the H-/Z-47 is used with an 8080A central processor. The Z-80 CPU board for the H-8 includes the extended configuration option. Older H-/Z-89 models also need modification to use the 8-inch disk unit. Recent models—those with an external control to adjust video-screen brightness—can accept the H-/Z-47 as is. Once the hardware is properly configured, integrating the H-/Z-47 into an existing system amounts to little more than plugging it in.

Both Heath's version of the CP/M operating system and the company's own HDOS operating system come complete with device drivers for 8-inch as well as 5¼-inch drives. The presence of the 8-inch disk unit is determined automatically at the time of the initial bootstrap load by special configuration programs that are provided as part of the Heath software. New system disks created by the system-generation program (provided with each operating system) will "remember" what disk devices are available. This means the configuration process does not have to be repeated each time the system is loaded.

Heath's CP/M BIOS module includes all the source code for the disk drivers and device tables (the BIOS—basic input/output system—contains the hardware-dependent routines for a specific computer system). The corresponding source modules are also provided with the Heath operating system. The entire HDOS source code is available in printed form at extra cost. Heath's liberal policy with regard to source-code distribution is unusual and very welcome. While most users will never need the source for the operating system, it is critical for some specialized applications.

The H-/Z-47 can be used as either the primary or secondary disk unit in a system. The primary unit is the one from which the operating system is usually booted up. The H-8 computer (but not the H-/Z-89) permits the system to be booted from either the primary or the secondary unit. The Heath software manuals contain step-by-step instructions for generating new system disks for secondary drives. The operating systems that are distributed on 5¼-inch and 8-inch disks are identical, so no new software is required when H-/Z-47 is added to an existing system.

Conclusions

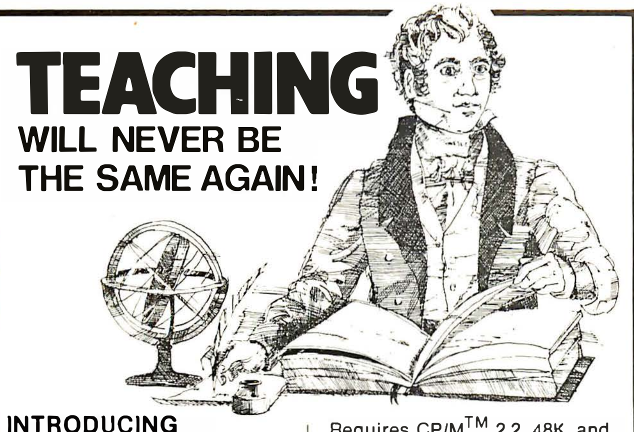
The H-/Z-47 provides a maximum of 999 and 1208K bytes of usable storage under HDOS and CP/M, respectively, for the Heath H-8 and Heath/Zenith-89 computers. It also provides compatibility with the standard IBM soft-sectored 8-inch disk format, substantially increasing the availability of software for the Heath/Zenith product line.

The kit version of the unit requires point-to-point wiring, since all but two small printed-circuit boards come preassembled. Construction took about 9½ hours. Heath's documentation is excellent, and the H-/Z-47 is easily integrated into existing Heath/Zenith computer systems without the addition of any new software. H-8 computers with an 8080A microprocessor and some older H-/Z-89 models require minor hardware modification, available at a nominal extra cost. Interface circuit boards are sold separately.■

Circle 25 on inquiry card.

Circle 322 on inquiry card.

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Circle 379 on inquiry card.

Assisted Instructional Development System

George Wolfe
James Madison University
Harrisonburg, VA 22807

Computer-assisted instruction (CAI) in public schools and colleges has increased in the last few years. Until now, however, two limitations made extensive CAI programs impractical for most school systems: (1) the time and cost involved in writing separate programs in BASIC, PILOT, or other language for each new lesson; and (2) the shortage of experienced educational programmers who could provide a school with its own personalized software.

The Assisted Instructional Development System (AIDS) represents a significant effort to overcome these constraints. The AIDS package, which includes both hardware and software, is a versatile educational system which makes creating CAI lessons cost-effective. It also does away with the instructor's need for extensive programming experience.

The economic catalyst for AIDS's development was the Norfolk (Virginia) Public School System, which has been experimenting with CAI for several years. The school system decided to move from the Hewlett-Packard HP3000 minicomputer system it had been using to individual Apple II microcomputers. The Small Business Computer Center of Virginia Beach was commissioned to develop an adaptable, easy-to-use CAI package that would meet the school's educational needs. The result of this project is the AIDS package.

At a Glance

Name
Assisted Instructional Development System (AIDS)

Use
Comprehensive computer-assisted instruction (CAI) system

Manufacturer
Instructional Development Systems
2929 Virginia Beach Blvd.
Virginia Beach, VA 23452
(804) 340-1977

Price
$345

Features
AIDS interface card with on-board calendar/time clock; 5¼-inch disk in Apple DOS 3.2 or 3.3 (demonstration disk available upon request for $25)

Language
Applesoft BASIC with supplementary machine-language subroutines

Hardware required
Currently for Apple II Plus with 48K bytes of RAM, TRS-80 version available soon

Documentation
200-page instruction manual in a 3-ring binder

Audience
Elementary and secondary schools and colleges—especially those with limited access to experienced programmers

The System

Through elaborate use of text files and string variables, AIDS allows teachers with virtually no programming experience to write elaborate CAI lessons. A teacher simply types in the lesson and then inputs questions pertaining to the lesson. The questions must be in the standard objective formats of true/false, multiple choice, or short answer. A special string search option enables the computer to search for any *keyword* the teacher may be looking for in a student response.

The instructor can input personalized reinforcing responses for correct and incorrect answers. A *failure message*, which the teacher can input, informs the student that he or she did not enter the correct response. A *hint* feature also exists for the student if a question poses great difficulty. The teacher has the option to include this feature in any question—without limit to the number of hints that can be given for each question. The number of questions per lesson is limited only by the storage space available on the lesson disk.

Anywhere Public Schools

Best School System — Title I Language Arts — Page 1

Daily Work Report

Teacher: Jane Sumter

Student Names	ID Number	Lesson	Subject	Number R/A	Remarks
Billings, Shelia	32309	5430	Punct.	10/20	Needs help
Goodard, Vick	32310	Test	Capitiz.	34/40	Score C +
Hilton, Wilt	32311	4580	Verbals	20/20	Excellent
Johnson, Mary	32306	3218	Nouns	37/40	Excellent
Johnson, Mary	32306	3211	Nouns	15/20	H.H. assign#2
Limming, Rob	32305	7809	Dictionary	17/20	Score B +

Table 1: *The Daily Report, one of the three reports generated by the Assisted Instructional Development System (AIDS), consists of a daily summary of all students' completed lessons.*

Anywhere Public Schools

Best School System — Title I Language Arts — Page 1

Name Listing Report

"Usage Report"

Teacher: Jane Sumter

Name	ID Number	Use Time (hrs)	Sessions
Billings, Shelia	32309	1.13	4
Dillinger, Larry	32333	0.27	1
Goodard, Vick	32310	2.00	8
Hilton, Wilt	32311	1.28	5
Johnson, Mary	32306	1.48	7

Table 2: *The Usage Report shows the number of hours and sessions each student used the system.*

Any City's Public School System

Best School System — Title I Language Arts — Page 1

"Student Report"

Teacher: Sally Smith

Student: John Bendzunas — ID#32102

Lesson	Subject	Number Right/Attempt	Percent Correct
3203	Adjectives	12/20	60
2133	Verbals	19/20	95
2154	Verbals	19/20	95
2134	Verbals	18/20	90
Test	Verbals	38/40	95
3231	Adjectives	15/20	75
2378	Adjectives	20/20	100
Totals		141/160	87

Table 3: *The Cumulative Student Report lists all lessons attempted by an individual student during the standard nine-week session.*

CAI Options

Each student is assigned an ID number for reporting purposes, but lessons can call the student by name, which adds a personal touch. Exercises can be presented in either a timed or nontimed format for the entire lesson or for individual questions. As the student works through the lesson(s), the system keeps an ongoing record of the student's usage and performance. After each lesson is completed, AIDS displays lists of the number of problems attempted, number of correct and incorrect answers, percentage score, and next assigned lesson.

With the *lesson-branching* option, students can be assigned an additional exercise based on their performance during a previous lesson. For example, an excellent score permits a branch to an enrichment lesson, average performance can branch to a reinforcing exercise, or a low score to a remedial one. A message file allows the teacher to make a follow-up assignment in a text, workbook, or other supplementary material.

Three types of permanent records are kept automatically by the system on student performance:

1. Daily report, an itemized account of the work done by a student on a given day (see table 1)
2. Usage report, a record of system usage in terms of hours and number of individual student sessions (see table 2)
3. Cumulative student report, a cumulative listing of all lessons taken by the student over a nine-week period (see table 3)

In addition to these lesson-design options, AIDS makes possible multiple lesson assignments that can be given in a specified order. Entire curriculum modules can then be developed on the system. When used, this feature supersedes the AIDS lesson-branching option. Finally, a lesson index lists all the lessons contained on a lesson disk for easy access to any material filed either by number or name.

Editing Features

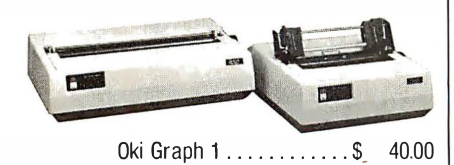
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AEC-2	Cable to Atari	$ 19.95
RSC-2	RS-232 cable	$ 25.00
TRSE-1	Cable to TRS-80	$ 18.95

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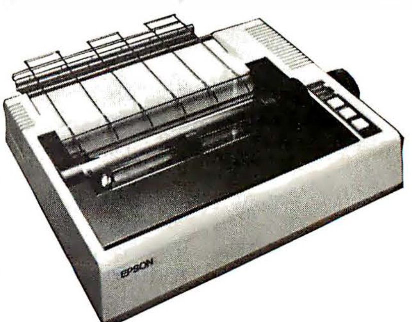
8510ADC	Pro/Writer serial & parallel	$ 695.00



8510AP	Pro/Writer, parallel	$ 499.00
1550	Pro/Writer II serial & parallel	Call for price
F10-40PU	Printmaster, parallel	$1,495.00
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MX-80	80-column dot matrix	Call



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MX-100	132-column dot matrix	Call

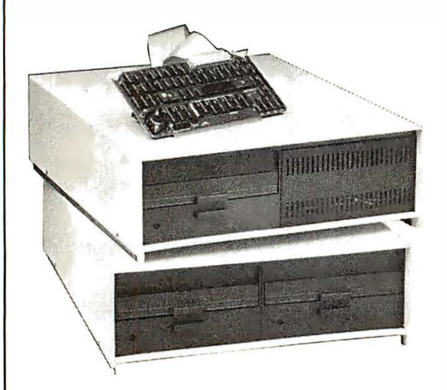
*Graphtrax Plus standard on all models

INTERFACES & CABLES

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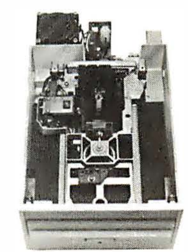


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Sanyo	DM 5012/12" B & W	$270.00
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830	Acoustic Modem	$159.00
850	Interface Module	$175.00
CX30-04	Paddle Controls	$ 17.95
CX40-04	Joysticks (pair)	$ 17.95
A16KA	16K RAM Board	$ 45.00

Components

4116's (200 nS)/5290-3
Apple, TRS-80, Heath

1-15	$1.50 each	50-99	$1.30 each
16-49	$1.40 each	100 up	$1.20 each

Circle 36 on inquiry card.

teachers to edit existing lessons easily. For example, a lesson may be added to or deleted from a disk at any time. Any component of a question (i.e., text, correct- or wrong-answer groups, hints, unexpected replies, or failure messages) can be modified without altering the other components of the question. Changes in branching direction or performance criteria for the next lesson can also be made at any time. Student records—including name, ID number, special assignments, lessons completed, scores, and hours of usage—can be added, deleted, or changed without affecting the remaining data in the file.

Finally, complete lessons may be displayed for section-by-section editing on the video screen or on a line printer. Because lesson-text editing is done line by line, minor corrections can be inserted without having to retype the entire lesson. One inconvenience accompanies line-by-line editing. Each line of a lesson is a different string variable within the program. If one notices an error in a previous line when editing or writing a lesson, it is impossible to return to that line by moving the cursor backward. Instead, the teacher must begin the lesson-editing routine anew in order to make the correction. This inconvenience can be avoided if the lesson is carefully proofread and care is taken to avoid typing errors.

Documentation

Accompanying the AIDS hardware and software is a 200-page, 6-chapter instruction manual that comes in a 3-ring binder. This manual is designed to give the user a thorough understanding of all the system's features. A demonstration disk is also available for potential buyers desiring to review the system themselves.

Hardware/Software

The Assisted Instructional Development System is currently available for the Apple II Plus microcomputer with 48K bytes of RAM and DOS 3.2 or 3.3. (According to a spokesperson for Instructional Development Systems, the company intends to make the AIDS package available for Radio Shack's TRS-80 microcomputers.) In addition to the program and instruction manual, the AIDS package includes a hardware interface card with an onboard calendar/time clock for dating records as well as timing lessons and student responses. The cost of the entire package is $345.

Conclusions

The AIDS package has been designed with the educator in mind and has several practical advantages over previous software approaches to CAI. A few shortcomings, however, should be mentioned.

First, the question/answer formats presently do not accommodate matching-type questions. Also, the lesson-design format favors an information-oriented approach, providing limited flexibility for alternative designs.

Second, after every three or four questions the disk must be accessed to load the next questions. Low-resolution animated graphics entertain the student while this loading is taking place, but, after a while, such frequent delays can become tedious.

Finally, although the graphics are an entertaining part of the system, no means is available (as yet) for incorporating graphics into the teacher's written lesson. According to Instructional Development Systems, this will be remedied in the near future by the inclusion of both low- and high-resolution graphics options. Other enhancement plans include a question-evaluation feature and a special interface to videotape or videodisc systems so that audio-visual material can be incorporated into the lessons.

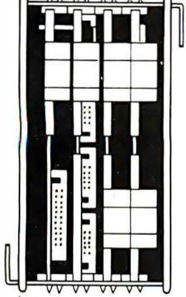
Despite any shortcomings, the AIDS package is a flexible, simple, and time-efficient way for teachers to create CAI lessons. Although it can never be a substitute for programming expertise, the Assisted Development Instructional System can fill the needs of many educators and will serve as a model for future systems dedicated to the development of CAI. ■

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Software Design: Methods & Techniques

Lawrence J. Peters
Yourdon Press
New York, 1981
248 pages
softcover, $23

Reviewed by
Paul S. Swanson
97 Jackson St.
Cambridge, MA 02140

Software Design: Methods & Techniques is a valuable source book for both the experienced software designer and the initiate. A compilation of various methods and techniques available to software designers, the book examines each method individually and summarizes its advantages and disadvantages.

Peters begins with a discussion of a quandary that software designers face. Like other engineers, software engineers require problem-solving methods. But while other engineers have access to fixed, known solution methods for a specific problem, no such clear-cut solutions are available to software engineers. In software, not only are the methods of solution in their stages of infancy, but the problems themselves are usually only vaguely defined. And that brings us to Peters' second major topic: defining design. Although he asserts that design has never been adequately defined, he provides a thorough description of the subject from several viewpoints.

Software Design: Methods & Techniques addresses 44 of the many different methods currently used in software design representation, treating system architecture, design structure, database structure, and software behavior separately. Each category in turn contains several methods. Summary charts show the relative strengths and weaknesses of each.

Among the methods Peters presents is the design tree, from which many other methods are derived. The derivatives, however, either stress or ignore various items in the system and therefore have different strengths and weaknesses. Some methods are hybrids that combine advantages.

After exploring different approaches to design representation, Peters turns to software design methods. He divides these into three types: data-flow-oriented, data-structure-oriented, and prescriptive. Each is presented in synopsis form with descriptions, examples, and tables showing its relative strengths and weaknesses. Peters includes a list of references for those interested in further reading.

Peters' views on flowcharts struck me as particularly amusing in light of the emphasis I have heard placed on them. He seems to have the same opinion of them that I do—they simply answer the wrong question. At one point, he mentions that they were invented to document existing software. That they are used in the design stages of software may have some bearing on why many people I know dislike them so much.

After presenting the methods, Peters describes ways to combine them. As he points out, some methods are better suited to people who do the programming, while others are better suited to users. The section on forming a methodology offers guidelines for developing a software design tailored to a particular project.

Peters' book is not only pleasant reading but will make a good reference manual because specific information in it is easy to locate. The charts and diagrams are plentiful and, for the most part, very informative. And the order of the book makes for logical transitions from one section to the next.

I recommend *Software Design: Methods & Techniques* to anyone who assembles or plans to assemble larger software systems on any computer system. Any programmer who understands the value of using a disk for program and data storage would benefit substantially from the information presented in this book. ■

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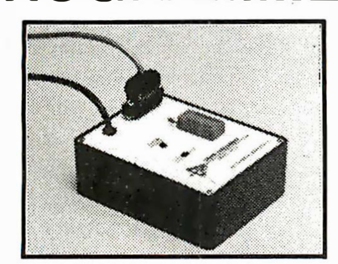
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Ask BYTE

Conducted by Steve Ciarcia

Tips on Homebrewing

Dear Steve,

I have started doing some research for my next project: building my own microcomputer and am interested in your book *Build Your Own Z80 Computer*. I have read several similar books and am getting ready to start design and construction; however, I have a number of questions:

- If I wish to incorporate a BASIC interpreter in my computer (not tiny BASIC but something akin to TRS-80 Level II, etc.), I presumably need to purchase a ROM (read-only memory) containing this program. Where do I find one? I haven't seen them advertised in the mail-order places in the popular magazines.
- Along the same line, where can I buy an interpreter for assembly language so that I can use mnemonic op codes instead of hexadecimal codes for programming?
- Is it possible for a home-built machine to be software-compatible with, say, the Radio Shack TRS-80 Model I? In other words, is it realistic to try and build a machine that will be able to load and run tapes or disks made for the TRS-80?
- Are there many different BASIC interpreters from which to choose? If so, which do you consider the best from a homebrewer's point of view?

David J. Abineri
Lakewood, OH

Microsoft BASIC is the de facto standard among BASIC interpreters and is the most popular BASIC in use today. Netronics Research & Development Ltd. (333 Litchfield Rd., New Milford, CT 06776, (800) 243-7428; in Connecticut, (203) 354-9375) markets an 8K-byte Microsoft BASIC for the Intel 8085 microprocessor that you might want to look into. A cassette version is available for $64.95 postpaid, and a ROM version is available for $99.95, plus a $2 shipping charge. The 8085 is 100% software-compatible with the 8080A and the Z80 (but it does not have all of the Z80 instructions).

For programming in assembly language, you need an assembler, not an interpreter. An assembler allows you to type in the instruction-set mnemonics and specify the program's start address. It then will "assemble" machine language starting at the specified address. Unfortunately, most of the assemblers sold today are geared toward a particular computer. However, I know an excellent book that provides a detailed explanation and complete listing of an assembler for an 8080-based system. It's called TEA: An 8080/8085 Co-Resident Editor/Assembler *by Christopher A. Titus. It's published by Howard W. Sams & Company (4300 West 62nd St., POB 7092, Indianapolis, IN 46206, (800) 428-3696; in Indiana, (317) 298-5400) and sells for $10.95.*

For a home-built machine to be software-compatible with the TRS-80, it would need the TRS-80 operating system and TRS-80 Level II BASIC. It is not realistic to try to build a TRS-80-compatible machine from scratch.

Rather than try to copy the TRS-80, I would suggest that, if you wish to build a Z80 computer, build it along the lines of my ZAP computer. Make it S-100-bus-compatible and add some memory and a floppy-disk controller. You can use CP/M (a disk operating system that can run a good Microsoft disk BASIC called BASIC-80) and you will have an unlimited amount of good software available.

The only real problem in custom building your own computer is that you are not software-compatible with anyone and you are constantly "reinventing the wheel" every time you write a program. . . . Steve

Where Does the BASIC Go?

Dear Steve,

I don't know much about computers yet, but I read or heard somewhere that if you wanted to use Pascal or any other language instead of the BASIC that comes with a certain system, you would replace the BASIC with Pascal in the ROM (read-only memory). Would I still have the BASIC in ROM or not? Can you explain it to me?

Thanks.

Keith McCreery
Portage, MI

Using Pascal in a computer that has BASIC in ROM does not affect the BASIC in any way. Pascal is just loaded into user memory. Normally, when another language is used, additional user memory is mapped into the memory-address space used by the ROM BASIC. In this way, the full addressing capability of the microprocessor can be used.

For example, in the Apple II computer, which has BASIC in ROM, supplementary languages are employed through the use of a "language card." This provides an additional 16K bytes of memory in place of the BASIC ROM when Pascal is used. The ROM BASIC is still in the computer, but it's bypassed. . . . Steve

Disturbing Line Disturbances

Dear Steve,

I own an Atari 800 that has been sent for repairs three times. I use it with an RCA XL-100 TV, which occasionally loses its screen or flickers for a second when the furnace switches on or off. However, the Atari does not "crash" during the display disturbance. Should I be concerned about the possibility of voltage spikes? I've heard that they can damage the internal parts of a computer, but can they damage a computer when it's off? What should I look for in a power-line protector? The literature from manufacturers seems inadequate.

Walter M. Lee
Olrey, MD

The symptoms you describe suggest that you are experiencing a voltage drop as well as possible spikes. Many devices on the market protect against voltage transients by clipping the peaks, thereby keeping them in a safe range, but such devices will not prevent the line voltage from dropping to the point where the computer memory becomes erratic.

From the fact that your Atari 800 does not "crash" during these disturbances, I would suggest a device to clip the transients. This will protect your computer from damage. These units are usually MOVs (metal-oxide



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varistors) and are rated by their energy absorption, usually in joules. Choose the largest one that you can find.

If the voltage spikes do not exceed the voltage-breakdown rating of the computer's plug transformer, there is little harm in leaving the computer plugged in after it is turned off. With the transient suppressor in the line, this problem vanishes. . . . **Steve**

Always Correct Clock

Dear Steve,

Some time ago I saw Don Lancaster's *TTL Cookbook* and became very interested in the "always correct clock" he talked about. I have tried to find the *Popular Electronics* issues he refers to but have not been able to do so (*Popular Electronics* does not have back issues that old). What I want to do is build that clock and bring the time value to a series of ports that connect with my S-100 system. With this approach, the clock will be correct so long as there is power for the computer. Any information you can supply would be helpful.

Tim R. Norton
Richardson, TX

The articles that Don Lancaster referred to were in the July 1972 and July 1973 issues of Radio-Electronics, *not* Popular Electronics. *What he also neglected to mention is the complexity of the receiver necessary to receive and decode the information broadcast at 60 kHz from station WWVB in Boulder, Colorado.*

Many S-100 clock boards on the market feature quartz crystals for their timing and should be accurate to within a few seconds a month. This is more than adequate for almost all conceivable timing applications. Some even have onboard battery backup to maintain their accuracy when the computer is shut off. The ready availability and moderate cost of these boards makes them the obvious choice.

For further information, see my article "Everyone Can Know the Real Time" (May 1982 BYTE, page 34). . . . **Steve**

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+5V
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2N3904
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1K
470Ω
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1K
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Figure 1

Composite Video from PETs

Dear Steve,

I own a Commodore PET 2001 computer with the old ROM (read-only memory) set. I recently purchased a Sanyo DM5112CX video monitor that I intend to use along with the PET's 9-inch monitor. Are you aware of a simple circuit that would take the signals from the PET and give me the composite-video signal that I need for the Sanyo? From the PET, I can easily get the following signals:

horizontal drive (TTL)
vertical drive (TTL)
video (TTL)

I can also get a +5-volt signal from the main logic board.

David Rene Anatol
Philadelphia, PA

Obtaining a composite-video signal from the horizontal sync, vertical sync, and video signals from the PET 2001 is very easy. The circuit shown in figure 1 is a video combiner that transforms the three separate inputs into a composite-video output. . . . **Steve**

Z8-based Voice-Recognition System

Dear Steve,

I'm working on a voice-recognition system using the Zilog Z8 microprocessor. I need advice on interfacing the Z8 board with an inexpensive speech recognizer that handles 32 words.

I'm a rank beginner.

Robert J. Marek
Waltham, MA

Interfacing a voice-recognition system to the Z8 is not difficult because there are sufficient I/O ports for the hardware portion of it. The tiny BASIC may not be sophisticated enough, so you may have to use machine language.

Since its initial presentation in the July and August 1981 BYTEs (see "Build a Z8-Based Control Computer with BASIC," Part 1, July, page 38; Part 2, August, page 50), many accessories have become available for the Z8-BASIC Microcomputer from The Micromint (917 Midway, Woodmere, NY 11598, (800) 645-3476; in New York, (516) 374-6793). In addition to cross assemblers that run on TRS-80 and CP/M systems, The Micromint has a memory, parallel I/O, and cassette-interface expansion board; a motherboard; and an EPROM (erasable programmable read-only memory) programmer. Other peripherals are in the works.

*An excellent article by James R. Boddie, "Speech Recognition for a Personal Computer System," appeared in the July 1977 BYTE (see page 64). You can also read "An Extremely Low-Cost Voice Response System" by James C. Anderson (February 1981 BYTE, page 36), "Speech Recognition: Turning Theory to Practice" by George R. Doddington and Thomas B. Schalk (*IEEE Spectrum, *September 1981, page 26), and my article "Use Voice Prints to Analyze Speech" (March 1982 BYTE, page 50). With help from these articles, you should be able to write the necessary software. . . .* **Steve**■

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:
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Circle 1 on inquiry card.

Software Received

Logo

Apple Logo, documentation includes *Apple Logo: An Introduction to Programming Through Turtle Graphics* and *Apple Logo: Reference Manual*. For the Apple II; floppy disk, $175. Logo Computer Systems Inc., 222 Brunswick Blvd., Pointe Claire, Quebec H9R 1A6, Canada.

Krell Logo, documentation includes *Logo for the Apple II, Logo for the Apple II: Technical Manual, Alice in Logo-land Primer, Logo Teacher's Manual*, and a one-year subscription to *The Logo and Educational Computing Journal*. For the Apple II; floppy disk, $149.95. Krell Software Corp., 1320 Stony Brook Rd., Stony Brook, NY 11790.

Terrapin Logo, documentation includes *Terrapin Logo Tutorial* and *Logo for the Apple II: Technical Manual*. For the Apple II; floppy disk, $149.95. Terrapin Inc., 678 Massachusetts Ave., Cambridge, MA 02139.

TI Logo, documentation includes *TI Logo*. For the TI-99/4 and TI-99/4A; command module (ROM cartridge) and cassette or floppy disk, $129.95. Texas Instruments Customer Relations, POB 53, Lubbock, TX 79408.

Apple

Apventure to Atlantis, an adventure-type game in which you become a nobleman struggling to prevent the enslavement of mankind by the Atlanteans. Includes graphics, sound, and personality definition for your player. For the Apple II; floppy disk, $40. Synergistic Software, 5221 120th Ave. SE, Bellevue, WA 98006.

Bandits, an arcade-type game in which you must protect a lunar supply base from thieves. You are armed with a laser cannon and shields, but the alien thieves have even more imaginative weapons. For the Apple II; floppy disk, $34.95. Sirius Software Inc., 10364 Rockingham Dr., Sacramento, CA 95827.

Cannonball Blitz, an arcade-type game where you must climb Nutcracker Hill and destroy a castle while dodging cannonballs. For the Apple II; floppy disk, $34.95. On-line Systems, 36575 Mudge Ranch Rd., Coarsegold, CA 93614.

Cricketeer, an arcade-type game. You must get your cricket across the highway and the river into his home. For the Apple II; floppy disk, $29.95. The Software Farm, 3901 South Elkhart St., Aurora, CO 80014.

Crossfire, an arcade-type game. Aliens have invaded the city and you must patrol the streets trying to destroy them while eluding laser fire. For the Apple II; floppy disk, $29.95. On-line Systems (see address above).

Cyclod, an arcade-type game. You control an eyeball that must build walls to smash or trap snakes. For the Apple II; floppy disk, $29.95. Sirius Software (see address above).

Dietician, a program to help you plan your daily diet, includes food values for more than 700 foods. For the Apple II; floppy disk, $59.95. Dietware, POB 503, Spring, TX 77373.

Disc Utility, this utility allows you to recover lost files, patch to any sector, display ASCII and hexadecimal characters on screen, and reorganize your disk. For the Apple II; floppy disk, $50. Answer Corp., 502A North Second Ave., Sandpoint, ID 83864.

Dueling Digits, an arcade-type game. You must shoot and capture numbers and mathematical operands and arrange them in a logical order. For the Apple II; floppy disk, $29.95. Broderbund Software, Entertainment Software Division, 1938 Fourth St., San Rafael, CA 94901.

Financial Records Manager, a personal financial-management package. For the Apple II; floppy disk, $44.95. Cybertech, Suite 404, 1500 West Shaw, Fresno, CA 93711.

Karel the Robot, an introductory Pascal programming course. You control a computerized robot by programming its actions with structured programs. For the Apple II; floppy disk, $85. Cybertronics International Inc., Software Publishing Division, 999 Mount Tremble Ave., Morristown, NJ 07960.

Labyrinth, an arcade-type game in which you must free the men trapped in an abandoned diamond mine from the clutches of various monsters. For the Apple II; floppy disk, $29.95. Broderbund Software (see address above).

The Last One, a program generator that develops complete BASIC programs from a user-designed flow chart. For the Apple II; floppy disk, $600. D. J. 'AI' Systems Ltd., Suite 480, Two Century Plaza, 2049 Century Park E, Los Angeles, CA 90067.

Lemmings, an arcade-type game. Before you go insane, you must prevent lemmings from overbreeding and going on a suicide run to the ocean. For the Apple II; floppy disk, $29.95. Sirius Software Inc. (see address above).

Letter Editor, a simplified word-processing program. For the Apple II; cassette, $20. Jalyn Software, 933 Mount Hood Dr., Pittsburgh, PA 15239.

Multiploy, designed for children from 4 to 14, this program presents basic mathematics problems in a game-type setting. For the Apple II Plus; floppy disk, $19.95. Reston Publishing Co., 11480 Sunset Hills Rd., Reston, VA 22090.

Property Management System, an income and expense tracking system for rental property. This system will handle single-family homes, condominiums, and multi-family housing. Operating statements for each building can be printed separately or combined in a consolidated operating statement. For the Apple II and III; floppy disk, $375. Realty Software Co., 1116 F 8th St., Manhattan Beach, CA 90266.

Rear Guard, an arcade-type game. You must maneuver around and destroy enemy spaceships as they attempt to overtake your vessel. For the Apple II; floppy disk, $29.95. Adventure International, POB 3435, Longwood, FL 32750.

Ricochet, an arcade-type game. This is an advanced version of pinball for one or two players. It has relocatable bumpers and demands strategy and thought. For the Apple II; floppy disk, $19.95. Automated Simulations, POB 4247, Mountain View, CA 94040.

Short Term Trader, a stock-market analysis package. It gives buy-sell direc-

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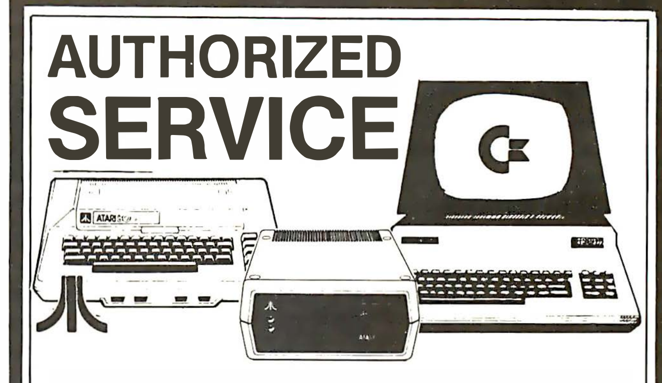
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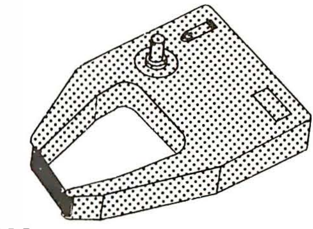
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tions on any stock you choose to follow, contains a call value section for puts and calls, and a commission costs estimating feature. For the Apple II and II Plus; floppy disk, $54. KCR Inc., Micro Statistics Division, POB 727, Sherman, TX 75090.

Sunpas, Sunop, and Tswing, a passive solar-heating analysis package designed for architects and engineers. These programs estimate yearly heating requirements of a passive solar building and perform nodal analysis thermal simulations. For the Apple II Plus; floppy disk, $700. Solarsoft Inc., POB 124, Snowmass, CO 81654.

Super Stellar Trek, a Star Trek-type game. This is an improved successor to the original Stellar Trek game. For the Apple II; floppy disk, $34.95. Rainbow Computing Inc., 9719 Reseda Blvd., Northridge, CA 91324.

Threshold, an arcade-type game. You must destroy a large number of alien targets that appear in successive waves with increasing speed. For the Apple II; floppy disk, $39.95, On-Line Systems (see address above).

Time Zone, an adventure-type game on six floppy disks. As you travel through time, you attempt to save humanity from alien domination. Estimated playing time: one year. For the Apple II; floppy disk, $99.95. On-Line Systems (see address above).

VC-Loader, a utility program to convert text or print files into DIF files for use with Visicalc, Visiplot, and Visitrend. For the Apple II Plus; floppy disk, $65. Micro Decision Systems, POB 1392, Pittsburgh, PA 15219.

Visicaids, Visicalc formatting aids for use with Visicalc files. It allows for variable width columns, long labels, splitting labels, formula printout, and print file reading. For the Apple II Plus; floppy disk, $44.95. Data Security Concepts, POB 31044, Des Peres, MO 63131.

Word Handler, a word-processing program that gives you a 66-column display without hardware modifications. It includes all standard word-processing functions such as lowercase, underlining, superscript, and unlimited tabs. All functions are displayed on the screen. For the Apple II; floppy disk, $199. Silicon Valley Systems Inc., 1625 El Camino Real #4, Belmont, CA 94002.

Zero Gravity Pinball, an arcade-type game. This game simulates pinball as it might be played in zero gravity. For the Apple II; floppy disk, $29.95. Avant-Garde Creations, POB 30160, Eugene, OR 97403.

Atari

Rear Guard, an arcade-type game (see description above). For the Atari 400 and 800; floppy disk, $29.95. Adventure International, POB 3435, Longwood, FL 32750.

Ricochet, an arcade-type game (see description above). For the Atari 400 and 800; floppy disk or cassette, $19.95. Automated Simulations, POB 4247, Mountain View, CA 94040.

CP/M

Accounts Payable, an accounts payable package. For CP/M with RM/COBOL; floppy disk, $1000. Micro Business Software Inc., Dover Rd., Willow Hill Building, Chichester, NH 03263.

Accounts Receivable, an accounts receivable package. For CP/M with RM/COBOL; floppy disk, $1000. Micro Business Software Inc. (see address above).

General Ledger, a general ledger package. For CP/M with RM/COBOL; floppy disk, $1000. Micro Business Software Inc. (see address above).

Order Entry/Billing, this package provides complete order-entry and billing functions including printing credit memos and invoices, receiving transaction entry, editing and posting with edit list and journal, order-entry, and interactive inventory control. Interfaces with other Micro Business Software accounting packages. For CP/M with RM/COBOL; floppy disk, $1000. Micro Business Software Inc. (see address above).

Perfect Writer, a word-processing program featuring virtual memory architecture that allows editing of documents larger than memory. Includes multiple file display and user-definable commands. For CP/M; 8-inch floppy disk, $389. Perfect Software Inc., 71 Murray St., New York, NY 10007.

Payroll, a full payroll system for a small business. Handles both hourly and salaried employees, prints checks and check register, payroll and deductions register, and performs all payroll calculations. Interfaces with the Micro Business Software General Ledger package, or it can run as a stand-alone system. For CP/M with RM/COBOL; floppy disk, $1000. Micro Business Software Inc. (see address above).

Sales Analysis, this program tabulates and prints sales analysis reports according to customer types and volumes, item type, category, and volume. Also analyzes sales force performance. For CP/M with RM/COBOL; floppy disk, $500. Micro Business Software Inc. (see address above).

UVMAC Z80—Absolute Macro Assembler, this utility uses source files similiar to CP/M assembly language. It supports file inclusion, conditional assembly, and listing control, and it produces .COM files. Includes a nonmacro version. For CP/M (Z80); floppy disk, $29.95. The Software Toolworks, 14478 Glorietta Dr., Sherman Oaks, CA 91423.

Exidy Sorcerer

Duel: A Dogfight in Space, an arcade-type game for two players. Written in machine-language, this high-resolution graphics game features two ships that accelerate, rotate, and fire weapons. For the Exidy Sorcerer; cassette, $20. Dayspring Computer Enterprises, POB 1910, Eugene, OR 97440.

Heath

Recipe-Master Version 1.01, a program to index and select recipes from a master file. It lets you display or print a recipe, create a sorted index, search for a specific recipe, and scan titles for specific keywords. For the Heath H-8 and H-89; floppy disk, $19.95. Interactive Micro Systems, POB 21007, Columbus, OH 43221.

IBM Personal Computer

Diskette Library Management System, a disk-library cataloging system that creates a file of the programs on each of your disks. Files can be updated and edited at any time. For the IBM Personal Computer; floppy disk, $100. Software Architects Inc., 27B Griffith Lane, Ridgefield, CT 06877.

Floppy-Disk Librarian, a disk-library cataloging system. This interactive set of programs maintains files and shows the location of each program on any particular disk. Requires PC DOS. For the IBM Personal Computer; floppy disk, $39.95. Little Bit, 469 Edgewood Ave., New Haven, CT 06511.

The Programmer, a program generator. Designed to run under BASICA, the Programmer allows you to create a program by selecting func-

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THE functions and commands in this package give you extended control over data and your PC-8001 system. These extensions to NBASIC provide complete conversion of time and date functions including days between dates and Julian dates. Extended string functions include justify, truncate, center, rotate, translate, shift, pack, and search. Array functions include masked search of both sorted and unsorted arrays, and insert in sorted arrays.

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tions from a series of menus. Once the function of the program has been defined, the Programmer writes the BASIC code. For the IBM Personal Computer; floppy disk, $495. Advanced Operating Systems, 450 St. John Rd., Michigan City, IN 46360.

Visicalc, electronic spread sheet. This latest version displays 63 columns by 254 rows and allows viewing the display through two windows. For the IBM Personal Computer; floppy disk, $250. Visicorp, 2895 Zanker Ave., San Jose, CA 95134.

TRS-80

Aircraft Instrument Approach Simulator, a program to train pilots for instrument landings. It features six types of approaches to an airfield and uses a full instrument panel display. For the TRS-80 Models I and III; cassette, $9.95. J. C. Sprott, 5002 Sheboygan #207, Madison, WI 53705.

Astroids, two arcade-type games. In the first game, you pilot a spaceship through an asteroid field. In the second game, you shoot the asteroids. For the TRS-80 Color Computer; cassette, $6.65. MFJ Electro Enterprises, POB 13076, Kanata, Ontario K2K 1X3, Canada.

Cubie Movie, a Rubik's Cube puzzle-solving program. For the TRS-80 Models I and III; cassette, $20. Five Stones Software, POB 1369, Station B, Ottawa, Ontario K1P 5R4, Canada.

Penetrator, an arcade-type game. Your mission is to carefully weave your way into an enemy base and destroy a neutron bomb cache. The enemies' defenses are composed of four increasingly difficult rings, with missiles, radar bases, and paratroopers abounding. This program features graphics, sound, and a customizing option. For the TRS-80 Models I and III; floppy disk or cassette, $24.95. Melbourne House, c/o Braverman, Cordon Co., 233 South Beverly Dr., Beverly Hills, CA 90212.

Property Management System, an income and expense tracking system for rental property (see description above). For the TRS-80 Models I and III; floppy disk, $375. Realty Software Co., 1116 F 8th St., Manhattan Beach, CA 90266.

Ricochet, an arcade-type game (see description above). For the TRS-80 Models I and III; disk or cassette, $19.95. Automated Simulations, POB 4247, Mountain View, CA 94040.

W9AV Morse Code Trainer, a Morse code training program. For the TRS-80 Models I and III; cassette, $9.95. J. C. Sprott (see address above).

VIC-20

Astroids, an arcade-type game (see description above). For the Commodore VIC-20; cassette, $6.65. MFJ Electro Enterprises, POB 13076, Kanata, Ontario, K2K 1X3, Canada.

Type-Test, a program to help you increase your typing speed. It includes a five-line speed test, where typing errors are subtracted and your speed is displayed. For the Commodore VIC-20; cassette, $9.85. MFJ Electro Enterprises (see address above).

ZX80/81

ZX81 Classics, Lunar Lander, K-Trek, Life, and **Mastermind**, games. For the ZX-81 and ZX-80 (8K ROM); cassette, $9.95. Lamo-Lem Laboratories, POB 2382, La Jolla, CA 92038. ■

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

BYTE's Bits

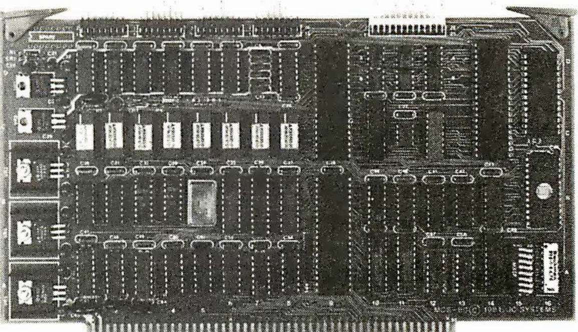
LDOS Update

Logic Systems has made a number of changes regarding its LDOS operating system since it was reviewed in the March 1982 BYTE. (See "LDOS-Disk Operating System for the TRS-80," by Tim Daneliuk, page 372.) One change is that the price has been lowered to $129. Another change involves the optional Extended Support Package (available for $25 per year). It now includes a subscription to a quarterly newsletter, access to the LDOS bulletin board on Micronet, and updates for only $5. If you do not elect to purchase the Extended Support Package, updates cost $10. Contact Logical Systems Inc., 11520 North Port Washington Rd., Mequon, WI 53092, (414) 241-3066. ■



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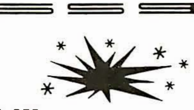
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The powerful 2-pass macro assembler features conditional assembly, local labels, include files and cross referenced symbol tables. MACRO-80C supports the complete Motorola 6809 instruction set in standard source format. There are no changes, constraints or shortcuts in the source language definition. Incorporating all of the features of our Rompack-based assembler (SDS80C), MACRO-80C contains many more useful instructions and pseudo-ops which aid the programmer and add power and flexibility.

The screen-oriented text editor is designed for efficient and easy editing of assembly language programs. The "Help Key" feature makes it simple and fun to learn to use the editor. As the editor requires no line numbers, you can use the arrow keys to position the cursor anywhere in the file. MACRO-80C allows global changes and moving/copying blocks of text. You can edit lines of assembly source which are longer than 32 characters.

DCBUG is a machine language monitor which allows examining and altering of memory, setting break points, etc.

The editor, assembler and monitor — as well as sample programs — come on one Radio Shack compatible disk. Extensive documentation included. MACRO-80C **Price: $99.95**

SDS80C — Our famous editor, assembler and monitor in Rompack. Complete manual included. **Price: $89.95**

PARALLEL PRINTER INTERFACE — Serial to parallel converter allows use of all standard parallel printers. You supply printer cable. **PI80C Price: $69.95**

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Color Forth consists of the standard FORTH Interest Group (FIG) implementation of the language plus most of FORTH-79. It has a super screen editor with split screen display. Mass storage is on cassette. Color Forth also contains a decompiler and other aids for learning the inner workings of this fascinating language. It will run on 4K, 16K, and 32K computers. Color Forth contains 10K of ROM, leaving *your* RAM for *your* programs! There are simple words to effectively use the Hi-Res Color Computer graphics, joysticks, and sound. The 112-page manual includes a glossary of the system-specific words, a full standard FIG glossary and complete source listing. COLOR FORTH ... THE BEST! From the leader in Forth, Talbot Microsystems. **Price: $109.95**

GAMES

Star Blaster — Blast your way through an asteroid field in this action-packed Hi-Res graphics game. Available in ROMPACK; requires 16K. **Price: $39.95**
Pac Attack — Try your hand at this challenging game by Computerware, with fantastic graphics, sound and action! Cassette requires 16K. **Price: $24.95**
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Clubs and Newsletters

OSI Group Meets in Miami

MSIG: OSI (Miami Special Interest Group: Ohio Scientific Inc.) meets monthly to exchange information on Ohio Scientific systems. The meetings are held on the first Thursday of each month at 656 Northeast 164 St., North Miami Beach, Florida. A software library is being set up. Membership fees are $8 per year. Contact the Miami Special Interest Group: OSI, 656 Northeast 164 St., North Miami Beach, FL 33162.

Newsletter Exchange Wanted

Northern Bytes, the monthly publication of Microcomputer Users International in Sault Sainte Marie, Michigan, contains club news and information as well as programs for many popular computers. The club is seeking to exchange newsletters with other microcomputer clubs and users groups anywhere in the world. If your club or group is interested, send a copy of your publication to Microcomputer Users International, c/o Jack Decker, Lot #155, 1804 West 18th St., Sault Sainte Marie, MI 49783.

Pocket Computer Group Formed

A club for TRS-80 Pocket Computer and Sharp PC-1211 users has been formed. For a $10 annual fee you will receive two free games, Draw Poker and Tic-Tac-Toe, and a year's subscription to the *Pocket Programming* newsletter. For details, write to John Riggs, 1114 Elaine, Livermore, CA 94550.

National Personal Computer Organization

Autumn Revolution '81 is a national organization of IBM Personal Computer owners, users, and interested parties. A $30 annual membership fee provides you with access to a toll-free technical hot line staffed with specialists who can answer most of your software and hardware questions, a newsletter, and software and technical libraries. Local chapters of Autumn Revolution '81 are being formed throughout the country. In the Chicago area, the local chapter, Neobyte, can be reached by contacting James L. Szafranski, 5195 Castaway Lane, Barrington, IL 60010, (312) 934-8133. In Utah, contact Nancy Williamson, Computerland Store, 161 East 200 South, Salt Lake City, UT 84111.

Complete details are available from Autumn Revolution '81, 10981 East 23rd St., Tulsa, OK 74129, (918) 438-4582.

Professional Newsletter

Computers in Psychiatry/Psychology is a clinical-resource newsletter for professionals interested in the use of computers in psychiatry and psychology. Each issue has descriptions of the computer-related activities of subscribers in such diverse fields as neuropsychiatric and MMPI (Minnesota multiphasic personality inventory) testing, problem assessment, biofeedback, computer psychopharmacology consultation, and electroencephalogram (EEG) analysis. Other features include summaries, reviews, original articles, and an ongoing bibliography and program catalog.

Individual subscriptions to *Computers in Psychiatry/Psychology* cost $25; institutional and foreign subscriptions are $35. Contact *Computers in Psychiatry/Psychology*, 26 Trumbull St., New Haven, CT 06511.

LAUGH in Hong Kong

LAUGH (Local Apple User Group—Hong Kong) meets on the third Thursday of the month on the twentieth floor of the New May House in Hong Kong. A newsletter is produced. Apple users traveling in the area are welcome to stop by. Contact LAUGH's secretary, Paul Deal, C12 Pearl Gardens, 7 Conduit Rd., Hong Kong, 5-221962, or call the club's president, Dr. Mike Rogers, at Kowloon 320865.

Logo Newsletters Available

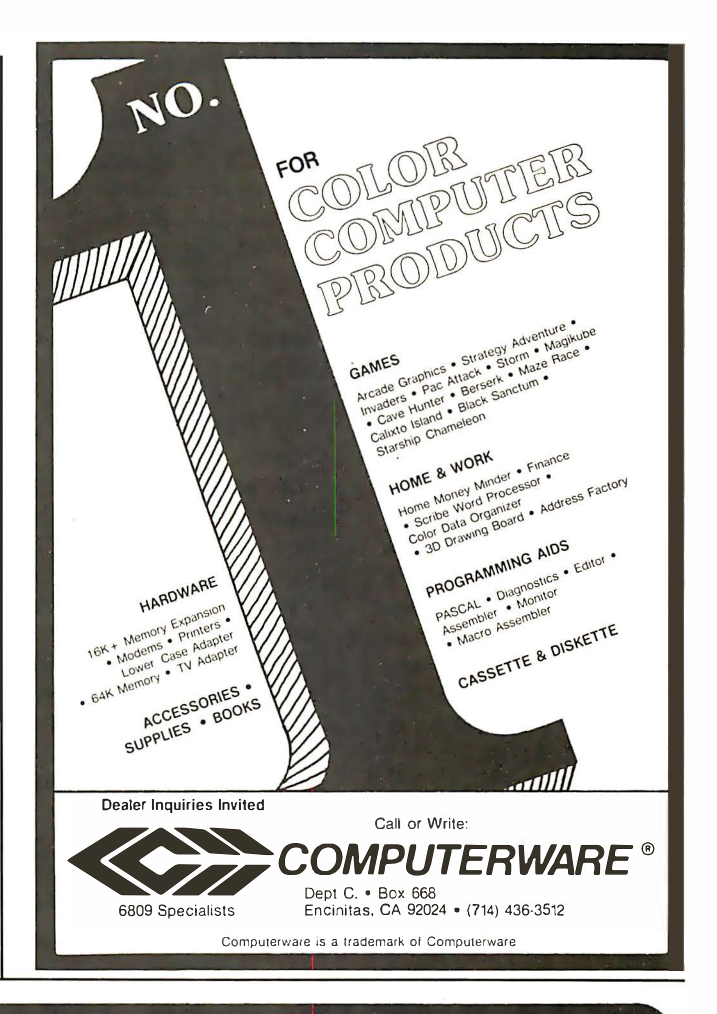
The following is a list of Logo newsletters: *The National Logo Exchange*, POB 5341, Charlottesville, VA 22905, Attn: Bill Mattson. Subscriptions cost $25 per year (9 issues).

Turtle News, Young People's Logo Association, 1208 Hillsdale Dr., Richardson, TX 75081, Attn: Jim Muller. Subscriptions are free for children and $15 per year for adults.

Logo and Educational Computing Journal, Krell Software Inc., 1320 Stony Brook Dr., Stony Brook, NY 11790. Subscriptions are available for $30 a year. ■

Circle 316 on inquiry card.





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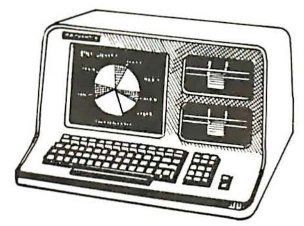


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Circle 180 on inquiry card.

Books Received

Algorithms for Graphics and Image Processing, Theo Pavlidis. Rockville, MD: Computer Science Press, 1982; 416 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-914894-65-X, $24.95.

BASIC Betting, The Micro-Computer Edge James Jasper. New York: St. Martin's Press, 1982; 283 pages, 15.2 by 23.3 cm, softcover, ISBN 0-312-06714-3, $9.95.

BCPL–The Language and Its Compiler, Martin Richards and Colin Whitby-Strevens. New York: Cambridge University Press, 1981; 173 pages, 15 by 22.8 cm, softcover, ISBN 0-521-28681-6, $10.95.

Bits 'n Bytes About Computing: A Computer Literacy Primer, Rachelle S. Heller and C. Diane Martin. Rockville, MD: Computer Science Press, 1982; 174 pages, 15.5 by 23.6 cm, hardcover, ISBN 0-914894-26-9, $17.95.

Compu Guide, The Consumer's Guide to Small Business Computers, Martha Eischen. Beaverton, OR: Dilithium Press, 1982; 157 pages, 13.5 by 21.3 cm, softcover, ISBN 0-918398-69-X, $14.95.

Discover FORTH, Thom Hogan. Berkeley, CA: Osborne/McGraw-Hill, 1982; 142 pages, 16.4 by 23.4 cm, softcover, ISBN 0-931988-79-9, $15.

Elementary BASIC, Henry Ledgard and Andrew Singer. New York: Vintage Books, 1982; 264 pages, 15.5 by 23.5 cm, softcover, ISBN 0-394-70789-3, $12.95.

Elementary Pascal, Henry Ledgard and Andrew Singer. New York: Vintage Books, 1982; 266 pages, 15.5 by 23.5 cm, softcover, ISBN 0-394-70800-8, $12.95.

Introduction to Digital Board Testing, R.G. Bennetts. New York: Crane, Russak & Company, 1982; 352 pages, 15.5 by 23.2 cm, hardcover, ISBN 0-8449-1385-0, $32.50.

Management Tools for Everyone, Steve M. Erickson. Princeton, NJ: Petrocelli Books, 1981; 170 pages, 16 by 24 cm, hardcover, ISBN 0-89433-131-0, $17.50.

Microprocessor Circuits, Volume 1: Fundamentals and Microcontrollers, Edward M. Noll. Indianapolis, IN: Howard W. Sams & Co., 1982; 109 pages, 21.2 by 28 cm, softcover, ISBN 0-672-21877-1, $9.95.

Numerical Analysis for Semiconductor Devices, Mamoru Kurata. Lexington, MA: Lexington Books, 1982; 269 pages, 16.4 by 23.3 cm, hardcover, ISBN 0-669-04043-6, $28.95.

Pascal, A Considerate Approach, David Price. Englewood Cliffs, NJ: Prentice-Hall, 1982; 194 pages, 17.5 by 23.5 cm, softcover, ISBN 0-13-652800-7, $9.95.

Pascal, An Introduction to Methodical Programming, 2nd edition, W. Findlay and D.A. Watt. Rockville, MD: Computer Science Press, 1981; 404 pages, 15.2 by 22.8 cm, softcover, ISBN 0-914894-73-0, $15.95.

A Practical Introduction to Computer Graphics, Ian O. Angell. New York: Halsted Press, 1981; 146 pages, 14.6 by 23.3 cm, softcover, ISBN 0-470-27251-1, $16.95.

Trade Secrets: How to Protect Your Ideas and Assets, James Pooley. Berkeley, CA: Osborne/McGraw-Hill, 1982; 145 pages, 16.9 by 24 cm, hardcover, ISBN 0-931988-72-1, $19.95.

Visicalc: Home and Office Companion, David M. Castlewitz and Lawrence J. Chisausky with Patricia Kronberg. Berkeley, CA: Osborne/McGraw-Hill; 182 pages, 21.2 by 27.6 cm, softcover, ISBN 0-931988-50-0, $15.99.■

This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

BYTE's Bugs

Lines Taken Out of Context

A production error occurred in the listing associated with the System Note "Epson MX-80 Print-Control Program for the Apple II," by Bill Starbuck (March 1982 BYTE, page 166). The completion of line 160 of the BASIC program (at the bottom of page 168) is actually the bottom four lines of page 169 (erroneously attached to line 440, which then correctly continues at the top of page 170). We regret the error.■

Event Queue

August 1982

August
Database Concepts and Design, various sites throughout the U.S. Sponsored by the American Management Associations (AMA), this five-day seminar is designed for data-processing managers, system designers, and other personnel involved in database activities. Topics include an overview of the database environment; evaluating and measuring performance, costs, and results; determining organizational needs and the systems and software to meet them; and implementing, integrating, and supporting the database within company plans and budgets. Highlighting this seminar is a comprehensive review of database products. Individual fees are $850 for AMA members and $975 for nonmembers. Team discounts are available. Contact AMA, 135 West 50th St., New York, NY 10020, (212) 586-8100. To register by phone, call (212) 246-0800.

August
Summer Seminars from Datapro Research, various sites throughout the U.S. and Canada. Among the seminars being offered are "Using Computer-Aided Design/Computer-Aided Manufacturing Systems: Planning, Equipment Selection, and Applications" and "Data Communications: Effective Network Design." Enrollment fees are $640 for Datapro subscribers and $690 for nonsubscribers. For more information, contact Datapro Research Corp., 1805 Underwood Blvd., Delran, NJ 08075, (800) 257-9406; in New Jersey, (609) 764-0100.

August
Engineering Summer Conferences, Chrysler Center for Continuing Engineering Education, North Campus, University of Michigan, Ann Arbor, MI. Among the conferences being offered are "Computers Image Analysis" and "Database Technology." For complete details, contact Engineering Summer Conferences, 200 Chrysler Center, North Campus, University of Michigan, Ann Arbor, MI 48109, (313) 764-8490.

August
Introduction to Microcomputing, various sites throughout the Midwest. Each participant in this three-day seminar will receive a Rockwell International AIM-65 computer and learn to program in machine language. Applications for instrumentation and process control will be emphasized. The seminar fee is $895, which includes the AIM-65; in-house presentations can be arranged. Details are available from the Foundation for Computer Education, POB 668, Ogden, IA 50212, (712) 843-2000.

August-September
Professional Development Seminars, various sites throughout the U.S. These seminars are presented by the Institute for Advanced Technology, a part of Control Data Corporation. Seminar topics include "Computer Operations Management," "Data and Site Security," and "Effective Management of Software Projects." Complete outlines can be obtained from the Registrar, Institute for Advanced Technology, Control Data Corp., 6003 Executive Blvd., Rockville, MD 20852. To register, call (800) 638-6590; in Maryland, (301) 468-8576. Information on in-house presentations is available from Pam Gallos at the address above.

August-September
Courses from Boeing Computer Services Company, various sites throughout the U.S. Among the topics to be covered are programming languages and aids, operating system facilities, and conversational systems. A complete catalog of courses, locations, and fees is available from Boeing Computer Services Co., Education and Training Division, POB 24346, Seattle, WA 98124, (206) 575-7700.

August-December
Courses from Fairchild Camera and Instrument Corporation, Santa Clara, CA. Among the courses being offered are "F9445 Family Introduction," "Pascal for Microprocessors," and "F680X Microprocessor Family." For more information, contact Fairchild Camera and Instrument Corp., Education Center, 3420 Central Expressway, Santa Clara, CA 95051, (408) 773-2161.

August-December
Courses from Don White Consultants, various sites throughout the U.S. and Canada. Among the courses being offered are "Interference Control: An Introduction to Electromagnetic Interference/Radio Frequency Interference/Electromagnetic Compatibility," "Electromagnetic Compatibility–Design and Measurement for Control of Electromagnetic Interference," and "Tempest–Design, Control, and Testing." Course fees range from $675 to $945. For complete details, contact Don White Consultants Inc., State Route 625, Gainesville, VA 22065, (703) 347-0030.

August-December
IEEE Computer Society Conferences and Meetings, various sites throughout the U.S., Europe, and Asia. Among the events scheduled are "Computer Vision: Representation and Control" and "The Annual Workshop on Computing to Aid the Handicapped." For a complete listing of conferences and meetings, contact the Executive Secretary, IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

August 8-14
Institute for Coordinator of Academic Computing, Potsdam, NY. Among the topics to be covered are user education, hardware planning, software location, conversion and adaptation, and exposure to instructional software and utility. For details, contact Dr. Fritz H. Grupe, Associated Colleges of the St. Lawrence Valley, Potsdam, NY 13676.

August 10-11
Computers—Can You Afford Not to Understand?, New York, NY. The fee for this executive briefing is $500. Further information can be obtained from the Registrar, Arthur Andersen & Co., Center for Professional Education, 1405 North Fifth Ave., St. Charles, IL 60174, (800) 323-0815; in Illinois, (800) 942-0851.

August 10-11
The Uncommon Carrier: New Opportunities in Carrier Services, New York, NY. For details, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

August 12-13
Microcomputers in Vocational Education Conference, Sheraton Inn, Madison, WI. Attendees will have access to both computer information for beginners and advanced applications of vocational education-related software.

The registration fee is $35. For more information, contact Judy Rodenstein or Roger Lambert, Vocational Studies Center, 964 Educational Sciences Building, 1025 West Johnson St., Madison, WI 53706, (608) 263-4367 or (608) 263-2704, respectively.

August 15-19
The Second International Computer Engineering Conference and Exhibition, Sheraton Harbor Island Hotel, San Diego, CA. This conference is sponsored by the Computer Engineering Division of the ASME (American Society of Mechanical Engineers). More than 50 exhibitors will display computer-engineering products, information, and services. The conference will feature technical sessions on more than 60 topics ranging from interactive graphics, personal computing by means of programmable calculators, computer-aided design and manufacturing, and robots. For complete details, contact the ASME, 345 East 47th St., New York, NY 10017, (212) 644-7100.

August 16-20
The National Conference on Artificial Intelligence, Carnegie-Mellon University and the University of Pittsburgh, Pittsburgh, PA. Among the topics to be addressed are expert systems, robotics, computational vision, programmable automation, game playing, and knowledge representation. Other features include an exhibition program and a two-day tutorial program providing a nontechnical look at key areas of artificial-intelligence research. Complete conference details are available from the American Association for Artificial Intelligence, 445 Burgess Dr., Menlo Park, CA 94025, (415) 328-3123.

August 17-18
The Uncommon Carrier: Opportunities in Carrier Services, Palo Alto, CA. For details, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

August 23-24
Personal Computer Market Opportunities and Pitfalls, the Anatole, Dallas, TX. The fee for this seminar is $495. For more information, contact Future Computing Inc., 900 Canyon Creek Square, Richardson, TX 75080, (214) 783-9375.

August 31-September 3
Systems Project Management, Chicago, IL. The fee for this course is $900. Complete details will be furnished by the Registrar, Arthur Andersen & Co., Center for Professional Education, 1405 North Fifth Ave., St. Charles, IL 60174, (800) 323-0815; in Illinois, (800) 942-0851.

September 1982

September 1-3
European Conference on Integrated Interactive Computing Systems (ECICS '82), Stresa, Italy. Among the topics to be covered are software architecture, user interfaces, system software and hardware, knowledge support, activities management, office information systems, and computer-aided design systems. For details, contact Maria Simi or Pierpaolo Degano, Istituto di Scienze dell'Informazione, Corso Italia 40, I-56100 Pisa, Italy, (50) 40862; Telex, 500371 CNUCE.

September 2-3
Indiana Computer Expo (ICE), Indianapolis Convention Center, Indianapolis, IN. This exposition will feature

exhibits of computer software and computer-related materials and services. Show details are available from Ernie Kerns & Associates, Suite 201, 2555 East 55th Place, Indianapolis, IN 46220, (317) 259-8111.

September 5-9

Euromicro 1982, Haifa, Israel. This conference is made up of scientific sessions, tutorials, panel discussions, industrial programs, and exhibits. Among the topics to be addressed are system architecture, hardware and software tools, network structure, and education. Highlighting this event is the international Euromouse competition for maze-solving mobile robots. For details, contact Euromicro, 4, Place Félix Eboué, 75012 Paris, France, (1) 341-08-46; Telex 211801.

September 9-11

The First Annual Meeting of the Microcomputer Users Group of the University System of Georgia (MUG/USG), Georgia Southern, Statesboro, GA. This meeting will feature demonstrations, talks, tutorials, and panel discussions on various applications of microcomputers in the classroom, laboratory, and office. Other features include vendor demonstrations and displays. For further details, contact Fred Henneike, Georgia State University, Atlanta, GA 30303, (404) 658-3120, or Richard Stracke, Augusta College, Augusta, GA 30910, (404) 868-3706.

September 9-12

The Fifth Personal Computer World Show, Barbican Centre, London, England. This is the largest computer show held in the United Kingdom. For complete details, contact Personal Computer World, 14 Rathbone Place, London W1P 1DE, England, 01-631 1433.

September 12-15

Design Engineering Technical Conference, Keybridge Marriott, Washington, DC. For information on this conference, contact the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St., New York, NY 10017, (212) 644-7740.

September 13

Knowledge Engineering in the 1980s, Chicago, IL. This executive briefing provides an overview of the power and potential of artificial intelligence. It is designed to introduce executives and senior technical personnel to the concepts of knowledge engineering and knowledge systems. Topics to be covered will assist participants in assessing the utility of knowledge engineering, pinpointing areas of impact, and outlining costs and strategies for initiating knowledge-engineering projects. The fee is $750, which includes materials, luncheon, and a reception. For further information, contact Dina Barr, Teknowledge, 151 University Ave., Palo Alto, CA 94301, (415) 327-6600.

September 13-15

Advanced Electronic Data Processing Auditing Concepts, Phoenix, AZ. This course is designed for experienced computer auditors. Topics to be studied include advanced computer systems control concepts and methods of evaluating controls and techniques for testing integrity and application controls for online systems, database management systems, and distributed-processing networks. This course is presented by Coopers & Lybrand. Information is available from Marge Umlor, EDP Auditors Foundation, 373 South Schmale Rd., Carol Stream, IL 60187, (312) 682-1200.

September 13-24

Computer Science at UCLA, University of California, Los Angeles, CA. Sponsored by the Continuing Education in Engineering and Mathematics (CEEM), this UCLA Extension program is designed for engineers, managers, and other professionals needing a concentrated overview of an up-to-date, master's level computer-science curriculum. Participants may enroll in six minicourses from a total of 18. Each unit is based on a course presented by UCLA's Computer Science Department during regular academic sessions. Each course runs for one week, two hours per day, for a total of 10 lecture hours. Hands-on experience is not provided. The fee is $1750 for the complete two-week program. Full details may be obtained from UCLA Extension, CEEM Special Programs, POB 24901, Los Angeles, CA 90024, (213) 825-5010.

September 14-15

The Future Factory, New York, NY. For details, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

September 14-16

Mini/Micro Computer Conference and Exposition, Disneyland Hotel, Anaheim, CA. For complete details, contact Electronic Conventions Inc., Suite 410, 999 North Sepulveda Blvd., El Segundo, CA 90245, (213) 772-2965.

September 14-16

Wescon/82 High-Technology Electronics Exhibition and Convention, Anaheim Convention Center, Anaheim, CA. Among the topics to be

covered are analog and digital signal processing, office automation, and semiconductor technology. For more details, contact Electronic Conventions Inc., Suite 410, 999 North Sepulveda Blvd., El Segundo, CA 90245, (213) 772-2965.

September 20-24
COMPCON Fall '82, Capital Hilton Hotel, Washington, DC. This conference will focus on the principles behind work-station technology, including local area networks, operating systems, and new concepts in user interfaces. Topics of interest include reliability and availability techniques, network-wide databases, distributed architectures, network user environments, and standards. For information, contact COMPCON Fall '82, POB 639, Silver Spring, MD 20901, (301) 589-3386.

September 20-24
Auditing in the Contemporary Computer Environment, Oklahoma City, OK. This course is designed for internal auditors and financial and data-processing professionals. A comprehensive audit approach for computer-based systems will be presented. Topics on the agenda include how to evaluate controls, how to prepare an audit report, and how to design a program of tests using questionnaires, checklists, software tools, and flowcharts. Contact Marge Umlor, EDP Auditors Foundation, 373 South Schmale Rd., Carol Stream, IL 60187.

September 21-22
Word Processing/Information Systems Expo, Sheraton Washington Hotel, Washington, DC. This conference and exposition will address the trends and advances in the word-processing industry. Among the topics to be covered are word processing and office integration, productivity measurement, and levels of managing an organization. Further details are available from National Trade Productions Inc., Suite 206, 9418 Annapolis Rd., Lanham, MD 20706, (301) 459-8383.

September 21-23
Software/Expo-National, Expocenter, Chicago, IL. This show is sponsored by *Infosystems* magazine. For complete details, contact Software/Expo, Suite 400, 222 West Adams St., Chicago, IL 60606, (312) 263-3131.

September 23-25
The First International Conference and Exhibition on Medical Computer Science (Medcomp '82), Hilton Hotel and the University of Pennsylvania, Philadelphia, PA. This conference is sponsored by the IEEE (Institute of Electrical and Electronics Engineers) Computer Society's Technical Committee on Computational Medicine. It is a transdisciplinary forum for engineers, medical professionals, and biomedical and computer scientists. Papers and exhibits will focus on topics such as the history and evolution of computers in medicine, artificial intelligence, software and systems evaluation, and signal and image processing. For additional information, contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

September 28-29
The Future Factory, Sunnyvale, CA. For details, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

September 28-October 1
Computer Trade Forum, National Exhibition Centre, Birmingham, England. This

Event Queue

trade show will bring together vendors, original equipment manufacturers, dealers, distributors, retailers, service companies, and independent sales organizations. For complete details, contact Clapp & Poliak Inc., 245 Park Ave., New York, NY 10167, (212) 661-8410. In England, contact Clapp & Poliak Europe Ltd., 232 Acton Lane, London W4 5DL, 01-747-3131.

October 1982

October 1-2
The Third Annual Fall Conference on Classroom Applications of Computers, San Jose, CA. This conference is sponsored by Computer-Using Educators, a nonprofit corporation. Topics will cover all areas of curricula from preschool through post-secondary school. Workshops, field trips, school visits, commercial exhibits, and a banquet dinner with a keynote speaker will be featured. Participation in all events is by preregistration only. Conference information is available by writing to Don McKell, Computer-Using Educators, POB 18547, San Jose, CA 95158.

October 1-7
Electronics 82, Bella Center, Copenhagen, Denmark. This will be the largest electronics fair in Scandinavia this year. It will feature demonstrations, conferences, talks, seminars, and commercial exhibits ranging from automation equipment to technical magazines. Approximately 250 exhibitors, representing almost 1000 firms, are expected. For particulars, contact Bella Center A/S, Center Blvd., DK-2300 Copenhagen S, Denmark, (01) 51 88 11; Telex: 31188 bella dk.

October 4
Knowledge Engineering in the 1980s, Boston, MA. For details, see September 13.

October 4-8
Auditing in the Contemporary Computer Environment, Hartford, CT. For details, see September 20-24.

October 5-7
The Third Annual Southwest Semiconductor Exposition, Civic Plaza Convention Center, Phoenix, AZ. "Automation/Automania?" is the theme for this year's technical conference. Suppliers of equipment and materials dedicated to the semiconductor, printed-circuit board, and hybrid industries will attend. Among the issues to be explored are the latest trends in general wafer processing and printed-circuit board manufacturing, hybrids, automation, robotics, and automatic testing. Highlighting this conference will be a preventative-maintenance training forum. Contact Cartlidge & Associates Inc., Suite 1014, 491 Macara Ave., Sunnyvale, CA 94086, (408) 245-6870.

October 7-8
Workshop on Automotive Applications of Microprocessors, Hyatt Regency Hotel, Dearborn, MI. This workshop is a forum on applications of microprocessors to automobiles, trucks, vans, allied automotive products, plants, and processors. Topics of interest include engine control, engine and vehicle diagnostics, instrumentation and display, safety systems, drive train control, plant process and quality control, and test equipment. For further details, contact S. Murtuza, Department of Electrical Engineering, University of Michigan, 4901 Evergreen

Rd., Dearborn, MI 48128, (313) 593-5028 or (313) 593-5420.

October 8-11
Electronica, Hynes Auditorium, Boston, MA. This show will feature a wide variety of personal electronics equipment, including computers, electronic games, ham radios, and projection TV. For more information, contact Northeast Expositions, 824 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

October 10-14
Association of Records Managers and Administrators (ARMA) Annual Conference and Exposition, Atlanta, GA. This is ARMA's twenty-seventh annual meeting. Word processing, data communication, and other aspects of information storage and retrieval will be examined. Additional information can be obtained from National Trade Productions Inc., 9418 Annapolis Rd., Lanham, MD 20706, (301) 459-8383.

October 10-14
Issue '82, Monteleone Hotel, New Orleans, LA. This is the sixth annual conference of Issue, an independent nonprofit organization of SPSS Inc. software users and coordinators. Papers will address such topics as data analysis, research training, computer graphics, and training materials and documentation. Contact the Executive Coordinator of Issue Inc., POB 11385, Chicago, IL 60611, (312) 329-2400.

October 11-12
Personal Computer Peripherals Market Analysis, The Anatole, Dallas, TX. The fee for this seminar is $495. Further details are available from Future Computing Inc., 900 Canyon Creek Square, Richardson, TX 75080, (214) 783-9375.

October 11-14
The Ninth International Management Exposition and Conference, Info 82, New York Coliseum, New York, NY. Full particulars may be requested from Clapp & Poliak Inc., 245 Park Ave., New York, NY 10167, (800) 223-1956; in New York, (212) 661-8410.

October 12-13
The Future: Home, New York, NY. For details, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

October 13-15
Advanced Electronic Data Processing Auditing Concepts, Los Angeles, CA. For details, see September 13-15.

October 15-17
The Second Annual Symposium on Small Computers in the Arts, Philadelphia, PA. Papers, tutorials, workshops, a gallery display of computer-generated prints and plots, films and video tapes, and computer-generated music performances are parts of this event. Topics of interest include computer graphics and animation, computer-automated sculpture, choreography, designs, and computer-generated music. The Annual Philadelphia Computer Music Concert is the featured attraction of this symposium. Address inquiries to the Symposium on Small Computers in the Arts, POB 1954, Philadelphia, PA 19105.

October 17-21
The Thirty-first Annual Data Processing Management Association (DPMA) International Conference and Exposition, Chicago Marriott Hotel, Chicago, IL. This will be the largest show in the DPMA's history. More than 85 companies will exhibit office automation technologies and data- and word-processing equipment. A full conference program is planned. Contact National Trade Productions Inc., 9418 Annapolis Rd., Lanham, MD 20706, (301) 459-8383.

October 18-22
Auditing in the Contemporary Computer Environment, Tulsa, OK. For details, see September 20-24.

October 18-22
Maintainability and Availability Engineering of Equipment and Systems, University of California, Los Angeles, CA. This short course is for upper-level and product managers, designers, salespeople, field-service personnel, and for those involved in the management, conception, design, operation, and maintenance of equipment. Topics to be covered include distribution of times-to-repair components and times-to-restore equipment, the equipment mean-time-to-restore, and optimum preventive maintenance schedules for minimum total corrective and preventive maintenance cost. The fee is $825, which includes notes. A complete course outline is available from Continuing Education in Engineering and Mathematics, UCLA Extension, POB 24901, Los Angeles, CA 90024, (213) 825-4100.

October 19-20
The Future: Home, Palo Alto, CA. For information, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

October 21-24
EdCOM '82—The National Computer Conference and Expo for Educators, Los Angeles Convention Center, Los Angeles, CA. More than 200 seminars, workshops, demonstrations, and exhibits are planned. In-depth tutorials and hands-on sessions will be held. Topics of interest include computer-aided instruction, administrative uses of microcomputers, classroom management, programming, research applications, computer literacy, and authoring languages. Information is available from Jayne LaFountain, EdCOM '82, 2629 North Scottsdale Rd., Scottsdale, AZ 85257, (800) 528-2355.

October 24-26
Texas Association for Educational Data Systems (TAEDS) Eighteenth Annual Convention, Villa Capri Hotel, Austin, TX. The conference theme is "Computer Literacy for Education, Industry, and the Community." Contact Dr. Terry Bishop, Austin ISD, 6100 Guadalupe St., Austin, TX 78752.

October 25-27
Advanced Electronic Data Processing Auditing Concepts, Tulsa, OK. See September 13-15 for details.

October 25-27
The 1982 ACM (Association for Computing Machinery) Annual Conference, ACM '82, Dallas Hilton Hotel, Dallas, TX. Among the topics to be addressed are programming languages, artificial intelligence, office automation, networks, graphics, computers and the handicapped, and operating, database, and distributed systems. General conference information is available from William Burns, ACM '82 Chairman, E-Systems Inc., POB 226118, Dallas, TX 75266, (214) 272-0515, ext. 3916.

October 26-28
The First IEEE Computer Society International Symposium on Medical Imaging and Image Interpretation, ISMII '82, International Congress Center, Berlin, West Germany. This symposium is sponsored by the IEEE (Institute of Electrical and Electronics Engineers) Computer Society's Technical Committee on Computational Medicine. It will provide a transdisciplinary forum for biomedical and computer scientists, engineers, medical physicists, and physicians from universities, medical centers, industry, and government. Papers and panel discussions will examine a variety of topics including microscope imaging, medical computer graphics, medical device regulation, computer-aided diagnosis, and image analysis systems. Equipment will be displayed. A thorough description of ISMII '82 is available from the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

October 26-31
The Fourth International Office Trade Fair, Orgatechnik '82, Cologne, West Germany. More than 1300 companies from 25 countries will exhibit the complete spectrum of office and information system products. Among the concurrent events planned are the KTV—Congress for Text Processing, Dafta '82—Data Protection Conference, and Telecom '82 Germany—Congress for Telecommunications in Business and Industry. For further information, contact Messe- und Ausstellungs-Ges.m.b.H Köln, Box 21 07 60, D-5000 Cologne 21, West Germany; Telex: 8 873 426 a mua d.

October 30-November 2
The Sixth Annual Symposium on Computer Applications in Medical Care (SCAMC), Sheraton Washington Hotel, Washington, DC. Topics to be addressed include medical informatics, health-care administration, information systems in health care, and artificial intelligence in medicine. Panel discussions, workshops, applications and methods demonstrations, and commercial exhibits are on the agenda. Highlighting this show will be the final round of the student paper competition. Information is available from Bruce I. Blum, SCAMC—Office of Continuing Medical Education, George Washington University Medical Center, 2300 K St. NW, Washington, DC 20037, (202) 676-4285. ■

In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc, notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, POB 372, Hancock NH 03449. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

Using the LOOKUP Function in Visicalc

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According to feedback I get from users, the most difficult operation to understand in the Visicalc software package is the @LOOKUP function. In this article, I'll explain that function using as an example calculation of the 1980 federal income tax form 1040 for a joint return (see table 1).

The LOOKUP function in Visicalc is designed to take a value and compare it to a table of increasing values. This operation can be performed either across a row or down a column. When the program finds an amount greater than the value being tested, the LOOKUP function displays the entry immediately to the right (in column order) or immediately below (in row order) the value that appears just *before* the amount greater than the value being tested. In our example, the initial value is the taxable income and the range of values is defined by the income-level break-points in the tax-rate schedule.

In BASIC, the @LOOKUP function would be represented by the following formula:

IF (value) < = (number in range) THEN (result)

In Visicalc the result can be a fixed value or a calculated amount based on certain other information.

Let's see how the LOOKUP table is created (see table 2). First a title for the model is placed in columns A to D, row 1. Next a value of 0 is placed in column A, row 2 and a title is placed in columns B and C, row 2. The value at A2 will become the amount that is looked up in the table. Columns A, B, C, and D in row 3 all contain 0 values.

SCHEDULE Y—Married Taxpayers and Qualifying Widows and Widowers

Married Filing Joint Returns and Qualifying Widows and Widowers

Use this schedule if you checked Filing Status Box 2 or 5 on Form 1040—

If the amount on Schedule TC, Part I, line 3, is:		Enter on Schedule TC, Part I, line 4:	
Not over $3,400........		—0—	
Over—	But not over—		of the amount over—
$3,400	$5.500	14%	$3,400
$5,500	$7,600	$294+16%	$5,500
$7,600	$11,900	$630+18%	$7,600
$11,900	$16,000	$1,404+21%	$11,900
$16,000	$20,200	$2,265+24%	$16,000
$20,200	$24,600	$3,273+28%	$20,200
$24,600	$29,900	$4,505+32%	$24,600
$29,900	$35,200	$6,201+37%	$29,900
$35,200	$45,800	$8,162+43%	$35,200
$45,800	$60,000	$12,720+49%	$45,800
$60,000	$85,600	$19,678+54%	$60,000
$85,600	$109,400	$33,502+59%	$85,600
$109,400	$162,400	$47,544+64%	$109,400
$162,400	$215,400	$81,464+68%	$162,400
$215,400	....	$117,504+70%	$215,400

Married Filing Separate Returns

Use this schedule if you checked Filing Status Box 3 on Form 1040—

If the amount on Schedule TC, Part I, line 3, is:		Enter on Schedule TC, Part I, line 4:	
Not over $1,700........		—0—	
Over—	But not over—		of the amount over—
$1,700	$2,750	14%	$1,700
$2,750	$3,800	$147.00+16%	$2,750
$3,800	$5,950	$315.00+18%	$3,800
$5,950	$8,000	$702.00+21%	$5,950
$8,000	$10,100	$1,132.50+24%	$8,000
$10,100	$12.300	$1,636.50+28%	$10,100
$12,300	$14,950	$2,252.50+32%	$12,300
$14,950	$17,600	$3,100.50+37%	$14,950
$17,600	$22,900	$4,081.00+43%	$17,600
$22,900	$30,000	$6,360.00+49%	$22,900
$30,000	$42,800	$9,839.00+54%	$30,000
$42,800	$54,700	$16,751.00+59%	$42,800
$54,700	$81,200	$23,772.00+64%	$54,700
$81,200	$107,700	$40,732.00+68%	$81,200
$107,7.00	....	$58,752.00+70%	$107,700

Table 1: *Schedule Y from the 1980 federal income tax form 1040.*

About the Author

Robert E. Ramsdell, C.P.A., is a microcomputer consultant who lives and works in Rockport, Massachusetts.

	A	B	C	D	
1	1980 JOINT TAX LOOKUP				1
2	0	TAXABLE	INCOME		2
3	0	0	0	0	3
4	0	.14	3400	-476	4
5	294	.16	5500	-586	5
6	630	.18	7600	-738	6
7	1404	.21	11900	-1095	7
8	2265	.24	16000	-1575	8
9	3273	.28	20200	-2383	9
10	4505	.32	24600	-3367	10
11	6201	.37	29900	-4862	11
12	8162	.43	35200	-6974	12
13	12720	.49	45800	-9722	13
14	19678	.54	60000	-12722	14
15	33502	.59	85600	-17002	15
16	47544	.64	109400	-22472	16
17	81464	.68	162400	-28968	17
18	117504	.7	215400	-33276	18
19			1E12		19
20			TOTAL TAX	0.00	20

Table 2: *LOOKUP table using column format.*

Column A will now have the cumulative tax amounts typed in; column B, the tax percentages; and column C, the income-level break-points (see table 1). One additional amount (at location C19) must be entered, representing the highest possible taxable income. I have arbitrarily chosen 1E12 for this amount, because the majority of my clients don't have taxable income exceeding a trillion dollars.

Now the actual tax calculations can be entered into column D. At location D4 the following formula could be typed:

+B4*(A2−C4)+A4

This formula states: take the taxable income (A2) and subtract the income-level break-point (C4), multiply it by the tax rate (B4) and add the cumulative tax amount (A4). This formula may now be replicated with the following commands:

/R (return), D5 . D18 (return), R N R R

Finally, the @LOOKUP function is inserted at location D20 with the following formula:

@LOOKUP (A2, C3 . C19)

This formula states: take the taxable income (A2) and compare it to the values shown in the table (C3 to C19). When a value greater than A2 is found, back up one amount and print the result found in the column immediately to the right.

An important point to remember concerning a Visicalc idiosyncrasy is that determinant (or forward) references require recalculation, and to avoid this requires an awareness of Visicalc's calculation methods. The value to be looked up (in this case the taxable income) must appear *before* the LOOKUP table, and the @LOOKUP

	A	B	C	D	E	F	G	H	I
1	1980 JOINT TAX TABLE								
2	0	TAXABLE INCOME							
3		0	0	294	630	1404	2265	3273	4505
4		0	.14	.16	.18	.21	.24	.28	.32
5		0	3400	5500	7600	11900	16000	20200	24600
6		0	-476	-586	-738	-1095	-1575	-2383	-3367
7	0.00	TOTAL TAX							

J	K	L	M	N	O	P	Q	R	
									1
									2
6201	8162	12720	19678	33502	47544	81464	117504		3
.37	.43	.49	.54	.59	.64	.68	.7		4
29900	35200	45800	60000	85600	109400	162400	215400	1E12	5
-4862	-6974	-9722	-12722	-17002	-22472	-28968	-33276		6
									7

Table 3: *LOOKUP table using row format.*

function *after* the table has been seen in the calculation order. Remember that column calculations begin at location A1 and proceed downward to location *n*, then back to B1 and down to *n*, etc. Row calculations begin at A1 and proceed across to *n*, then back to A2 and across to *n*, etc. (see table 3).

Now let's take a look at table 4 to see how the calculation works. A taxable income of $26,000 has been entered at location A2. The @LOOKUP function at D20 takes this value and compares it to the table from C3 to C19. The first number greater than 26,000 in the table is 29,900, so the function drops back one value (to 24,600) and prints the calculation shown immediately to the right of that value, 4953. Table 5 shows how to accomplish these same calculations using row lookups instead of columns.

The @LOOKUP function has many more uses, and when used with the @MIN and @MAX functions it can be used to solve most problems involving conditional relationships. ■

	A	B	C	D	
1	1980 JOINT TAX LOOKUP				1
2	26000	TAXABLE INCOME			2
3	0	0	0	0	3
4	0	.14	3400	3164	4
5	294	.16	5500	3574	5
6	630	.18	7600	3942	6
7	1404	.21	11900	4365	7
8	2265	.24	16000	4665	8
9	3273	.28	20200	4897	9
10	4505	.32	24600	4953	10
11	6201	.37	29900	4758	11
12	8162	.43	35200	4206	12
13	12720	.49	45800	3018	13
14	19678	.54	60000	1318	14
15	33502	.59	85600	-1662	15
16	47544	.64	109400	-5832	16
17	81464	.68	162400	-11288	17
18	117504	.7	215400	-15076	18
19			1E12		19
20			TOTAL TAX	4953.00	20

Table 4: *LOOKUP table for a couple with $26,000 in total income.*

	A	B	C	D	E	F	G	H	I
1	1980 JOINT TAX TABLE								
2	26000	TAXABLE INCOME							
3		0	0	294	630	1404	2265	3273	4505
4		0	.14	.16	.18	.21	.24	.28	.32
5		0	3400	5500	7600	11900	16000	20200	24600
6		0	3164	3574	3942	4365	4665	4897	4953
7	4953.00	TOTAL TAX							

J	K	L	M	N	O	P	Q	R	
									1
									2
6201	8162	12720	19678	33502	47544	81464	117504		3
.37	.43	.49	.54	.59	.64	.68	.7		4
29900	35200	45800	60000	85600	109400	162400	215400	1E12	5
4758	4206	3018	1318	-1662	-5832	-11288	-15076		6
									7

Table 5: *LOOKUP table as in table 4 but in row format.*

BYTELINES

News and Speculation about Personal Computers

Conducted by Sol Libes

Random Rumors: Commodore International is said to have working prototypes of its new family of 16/32 microprocessors. The devices are expected to be upwardly compatible with the 6500 series microprocessors, and the company may begin shipping samples before year-end. However, expect to see an Intel 8088 or 8086 in the new 16-bit personal computer Commodore is expected to introduce soon. . . . You can expect Sears to expand the number of its Business Systems Centers to over 200 within the next few years. . . . IBM is rumored to be working on several new microcomputer projects: a second-generation personal computer, a portable personal computer, a low-cost consumer personal computer, and a professional work station. . . . Microsoft is expected to release version 2.0 of its MS-DOS (used on the IBM Personal Computer) this fall. Expect it to contain features such as multiple screen windows, string system commands, and stress networking. . . . Portia Isaacson predicts that we will soon see robot stores in addition to our current computer stores and software stores. She also predicts that software stores will follow a growth curve similar to that of computer stores, sharing a $1.5 billion market by 1989. . . . Intel is said to be negotiating with Microsoft to put Xenix in its software line as an option. In the meantime Intel is readying release 5 of its RMX operating system, which will be upgraded to a multiuser system. . . . Zenith is reportedly dubbing its new 16-bit system the Z-100; it may use the 68000 microprocessor and may also be available in kit form from Heath. A 16-bit microprocessor trainer might also be in the works. Heath, which already has 60 stores, is expected to open 10 more this year. Microcomputers are now approaching 50 percent of Heath sales. . . . The Marc operating system for Z80-based computers, which contains many Unix-like features, is expected to reach the market finally in the fall. It is from Vortex Technology, Culver City, California. . . . Digital Research is rumored to be working on 68000 versions of CP/M, MP/M and CP/Net. These versions are all currently running in-house and are expected to be released before year-end. . . . Univac and Control Data Corporation are expected to soon introduce Z80-based personal computers running CP/M, with communications facilities.

Word has it that Osborne Computer is readying a $500 personal computer, complete with software, for introduction possibly this year. In the meantime, the company expects to have 150,000 Osborne 1s installed by the end of this year.

IBM Rumblings: From disclosures of disk contracts being signed by IBM it is estimated that IBM expects to sell close to 1 million IBM Personal Computer systems by the end of 1984. The company has also just added 500 more employees to its Boca Raton, Florida, facility, which assembles the Personal Computers. . . . IBM reported worldwide net earnings of $768 million for the first quarter of 1982; that's up $38 million from the same quarter last year. Gross income for the period was over $7 billion, compared to $6.46 billion last year.

Apple Doings: Apple Computer Inc. reported that earnings for the first quarter of this year rose 50 percent while revenue rose 70 percent. A. C. "Mike" Markkula, Apple president, forecasted earnings of close to $14 million, as opposed to $9.2 million for the same period last year.

Apple is beginning to feel the effects of recent marketing decisions (e.g., Apple's controversial ban on mail-order sales) and competition from new entries into the field (most notably IBM). Revenue was fractionally below the previous quarter ($133.6 million).

Most industry analysts feel that sales of the Apple II have finally hit a plateau at an estimated 20,000 systems per month. It is also estimated that there are about 400,000 such systems presently in use. It is expected that Apple will finally announce a new version of the Apple II this summer. The new computer is expected to be compatible with the Apple II and have a standard 80-character by 24-line display with lowercase letters, plus several other enhancements; and it will be priced lower than the current version.

In the meantime, Apple has made another major marketing change that should have a considerable effect on its sales. Apple has terminated its central buying agreement with Computerland, the nation's largest chain of computer stores, in an attempt to gain control over the geographic locations of its retail outlets. Computerland wanted all of its current and future outlets to be able to sell Apples from any location Computerland desired. Apple wanted to be able to specify which new franchises could or could not sell Apples.

Independent Apple dealers have long been asking Apple to reduce the competition from so-called low-support dealers and have contended that mail-order companies and many Computerland dealers were guilty of low-support discount sales.

Apple already has agreements to sell directly to most Computerland dealers; however, these dealers will now have to pay a higher cost than under their previous central purchasing agreement. Since Computerland undertook to sell IBM's system, the chain's contribution to Apple's sales has declined.

Apple is also cracking down on dealers who have been "transshipping" to mail-order and telephone sellers. Reportedly, at least six Apple dealerships have been terminated for this reason. Apple has been discreetly purchasing systems from unauthorized dealers to track serial numbers and identify the transshippers.

The sum and substance of these policy changes is that Apple is attempting to build loyalty into its dealer base to offset existing and anticipated competition from IBM, Osborne, Digital Equipment Corporation (DEC), and several Japanese makers.

The $99.95 Personal Computer: Timex, well known around the world as a leading supplier of low-cost watches, has entered the personal computer market with a blockbuster. The company will be mass-merchandising an improved version of the Sinclair ZX81, to be called the Timex Sinclair 1000, at a list price of $99.95, and it's likely that we'll eventually see these machines discounted in chain department stores, drugstores, jewelry stores, and consumer electronics outlets at prices ranging down to $75.

Timex has been manufacturing the ZX81 for Sinclair and is currently pushing units

off the production line at a rate of 1 every 10 seconds. The Timex Sinclair 1000 will be distributed through over 100,000 retail outlets, starting with computer stores. Timex will also be offering a wide selection of game, educational, personal, Visicalc-like, and business software for the system. Predictions are that there may be as many as 1 million of these units out by the end of next year.

The Timex Sinclair 1000 contains 2K bytes of memory, compared to the ZX81's 1K bytes, and Timex expects to introduce shortly a communications interface and a thermal printer ($99.95 each). A 16K-byte memory module will be available for $49.95. Timex also disclosed that a more powerful computer is in the works. Could it possibly use the new flat video screen that Sinclair is developing?

The Sony System: Sony has finally decided to take the plunge and will enter the personal computer market with a Z80-based CP/M system. In a cabinet roughly the same size as that of an Apple II, it contains two of Sony's new 3½-inch floppy-disk drives, 64K bytes of memory, and 32K bytes of ROM (read-only memory) containing Sony-BASIC, which will be very similar to Microsoft BASIC. The basic unit without the drives will cost $1475. It will have 4 different graphics modes that range from 640 by 400 black-and-white pixels to 640 by 200 color pixels. It will have five slots for optional plug-in accessory cards and numerous other optional features. There will be plug-in options such as a cache 8-inch floppy-disk controller, an IEEE-488 interface, plug-in ROM and keypad interfaces, an 8086 card with 256K bytes of memory (to run either CP/M-86 or MS-DOS) and lots more. The basic unit includes sound, RS-232 and parallel ports, a clock/calendar, and a cassette interface.

Commodore Unveils New Units: Commodore has disclosed that it will soon introduce three new microcomputers: a 16-bit system and two "very low-cost" 8-bit systems. The 16-bit computer will be a dual-processor system using Commodore's new 6509 8-bit microprocessor and Intel's 16-bit 8088. It will have multiprocessing ability, an 80-column display screen, 256K bytes of memory, and dual floppy-disk drives with 680K bytes of storage. All three systems will accept plug-in Z80 or 8088 processors, enabling users to run CP/M-80 or CP/M-86. Prices of these systems should be significantly less than comparable machines currently on the market.

Commodore also disclosed that sales for the first quarter of this year rose to $82 million, up from $50 million for the same period last year.

Unix Where Art Thou: Despite advertisements in magazines, publicity releases and articles maintaining that Unix or Unix-like operating systems are available for microcomputers, I have yet to see any multiuser microcomputer systems being shipped (although I *have* received samples of *single-user* Unix-like systems and am aware that two or three companies have begun shipping these systems). Just what is the problem? It appears that, although it is written in the C language, Unix is still very difficult to convert for use on other systems. Because Unix was written to run on large minicomputer systems such as the DEC PDP-11, it is not easy to make multiuser versions run with decent speed on microcomputers. Therefore, many companies are spending an inordinate amount of time on refinements and optimization of the code.

The result is that we can expect Unix versions with various levels of implementation. The likelihood is that few of the microcomputer versions will be full implementations of Unix. Keep in mind also that there are several different versions of Unix currently in use in the minicomputer world. Thus there is the question of software compatibility between these different implementations, and application software transportability may turn out to be a serious problem.

It is interesting to note that, until last year, the overwhelming number of Unix users were *internal* to the Bell System; however, since last year, the number of commercial users granted binary licenses and the number of universities granted source licenses have increased. It has been estimated that over 90 percent of the universities in this country have Unix source code licenses.

Software Suppliers Doing Well: To a large extent the software industry is still a cottage industry, but things are changing. Just a few short years ago companies such as Digital Research, Microsoft, Micropro, and Visicorp were "basement" and "spare-room" operations. Today they are large corporations. Digital Research, creator of CP/M, MP/M, CP/Net, PL/I-80 and more, now has over 150 employees and will probably do over $20 million in gross business this year. Micropro, creator of Wordstar, last year earned $5.2 million and this year should earn well over $12 million.

Microsoft, which did not incorporate until July of last year, now has over 125 employees and anticipates a gross revenue of close to $30 million this year, up from $15 million last year. Visicorp (previously known as Personal Software Inc.) last year had revenues of more than $3 million, mostly from its Visicalc program.

Digital Research and Microsoft have already gotten venture capital money, which is usually a precursor to "going public" (offering stock for sale to the public) a la Apple Computer. Micropro plans to go public before this year is out.

Race for Space: Shelf space is the key to merchandising low-cost personal computer systems, and a battle is developing as personal computer vendors vie for that precious shelf space among mass merchandisers. Texas Instruments (TI), Atari, Commodore, and Nippon Electric Company (NEC) are currently fighting for acceptance by mass-merchandising chains such as J. C. Penney, K-Mart, Sears Roebuck, Woolco, and Montgomery Ward for machines such as the TI 99/4A, Atari 400, Commodore VIC, and NEC PC-6001. Apple is expected to enter the low-cost marketplace this year, and there are even rumors that IBM is developing a low-cost unit. However, Timex with its $99.95 machine may pull the rug out from under these companies.

The personal computer vendors estimate that over a million machines will be sold in 1983. TI has already had limited success selling systems through J. C. Penney, and Atari through Sears. Other consumer discount chains such as Tech Hi-Fi, Crazy Eddie, and Shack Electronics are also jumping onto the personal computer bandwagon.

The mass merchandisers are looking to use the hardware to draw traffic to sell software and peripherals. They think it might work out like the razor/razor-blade and record-player/record markets, where the profits are in the big aftermarket sales. In the meantime the traditional computer stores have dropped these low-cost products and are concentrating on the business marketplace, where performance, training, and support are important.

Who's on Top? In the traditional personal computer marketplace, the question is frequently asked,

"who is on top?" Apple last year had sales of $334 million, while Tandy reported computer sales of $370 million (21.3 percent of the firm's total sales). However, Tandy's figures include sales of its hand-held calculators and the more consumer-oriented Color Computer. IBM is not expected to become a major contender until it broadens out its distribution organization (which should happen soon).

Sales of personal computers are expected to increase by about 60 percent this year over last year and could total $2.7 billion. Although this year Apple and Tandy are again expected to fight it out for first place, IBM will probably be close behind. Other companies that are expected to carve out sizable chunks of this market are Commodore, Atari, Hewlett-Packard, Osborne, Zenith, Xerox, and NEC. The Japanese firms appear still to be developing their products and setting up their distribution organizations; therefore, they are not expected to become a major force in the U.S. market until late 1983 at the earliest.

What's Doing in Japan? NEC has introduced its new PC-8801 system in Japan (no word yet as to when the system will arrive in the U.S.) and, contrary to my recent prediction, it is using a Z80-like processor (the NEC μPD780, the same microprocessor used in the PC-8000). It is software compatible with the PC-8000 and has an enhanced ROM BASIC similar to the IBM Personal Computer BASIC. Further, it has such features as labels, interrupt handling, and special port handling commands. It sells for the equivalent of $950 in Japan.

The other hot sellers include the Sharp MZ-80C, the new Epson machine, the Toshiba Pasopia, and a fancy living-room system from Yamaha called the YIS. Hitachi has also introduced a new system called the MB-6891 using the 6809 microprocessor. All the new Japanese systems feature high-resolution (typically 640- by 200-pixel) color graphics.

Changing Disk Scene: Prices of 5¼-inch Winchester drives are dropping drastically in a price war that is shaking up the industry. Leaders in this battle are Seagate Technology and Tandon Corp., which are quoting large-volume order prices of as low as $650 per unit. The result is that retail prices are dropping. For example, Apple originally priced its hard-disk option for the Apple III at $4000. It is now selling for $2500, and the price should be under $2000 by year-end.

The first 5¼-inch disk drives typically stored 6 megabytes. Now, however, 10 and 20 megabytes are routine and capacities are expected to be pushed to over 60 megabytes next year. In fact, Micropolis introduced drives storing 25 and 38 megabytes at the recent National Computer Conference show. The company also introduced an 8-inch Winchester hard-disk drive with a capacity of 110 megabytes.

The Japanese are attempting to crack the U.S. hard-disk drive market. They have already shown drives at trade shows and are expected to start shipping units in large quantities soon. It is of real concern to U.S. disk vendors who fear that the Japanese may take over this market as they have the low-cost printer market. The Winchester disk market is expected to be threatened as early as 1984 by the optical disk, which will offer spectacular price and performance advantages.

Personal Robotics: Last year Jerome Hamlin constructed a robot "butler" at home. He named it Comro I and persuaded Neiman-Marcus to feature the robot, priced at $15,000, in its Christmas catalog. The store sold three. Hamlin is now working on a robot kit that he plans to sell for under $2000.

Heath has already demonstrated a prototype robot kit that it plans to introduce either later this year or next year for between $1500 and $3000.

Several companies are already selling computer-controlled arms and bodies in kit form that range in price from $700 to $2500, and there are rumors that some toy companies have developed prototypes of true robotic toys that will sell in the $300 to $500 price range.

So far, the personal robotics products and projects that have been built are awkward and not very useful, reminiscent of the early personal computers. But more and more experimenters are getting involved in robotics projects, and the likelihood is that we will soon see the fruits of these labors translated into a mushrooming new market.

Phone Set Goes Digital: Northern Telecom, Richardson, Texas, has introduced an integrated telephone/terminal called the Displayphone. Measuring just 11.5 by 14.5 by 8.5 inches and weighing only 13.5 pounds, it allows voice, data, and simultaneous voice and data calls. It has a built-in 7-inch 80-character by 25-line video display and a pull-out keyboard. It uses an 8085 microprocessor, 32K bytes of ROM, 64 bytes of memory with battery back-up, and Centronics-type parallel and RS-232 ports.

Not on Speaking Terms: Consumers are not taking to talking appliances. Sales of microprocessor-controlled appliances appear to be lagging and in some instances are declining. A case in point is the failure of talking microwave ovens. Apparently users, not only in the U.S. but in Japan and elsewhere, don't like to be talked to by a machine. Sales of microwave ovens that tell the user what to do next have been so bad that Mitsubishi Electric recently stopped producing talking ovens sold under the Panasonic and Quasar labels.

Random News Bits: There's a new game out called Tax Man in which an IRS agent chases a taxpayer through a maze that looks very much like a 1040 form. . . . Bible Research Systems, Austin, Texas, has released "THE WORDprocessor," consisting of eight floppy disks containing the entire King James version of the Bible. An Apple or TRS-80 user can scan and locate biblical references through a series of indexes. . . . Did you know that each year Japan graduates more engineers than the U.S., even though it has half the population?

Quote of the Month: "Software suppliers are trying to make their software packages more 'user friendly.' The best approach, so far, has been to take all the old brochures and just rubber stamp them with 'user-friendly' on the front cover."
Bill Gates, President
Microsoft

MAIL: I receive a large number of letters each month as a result of this column. If you write to me and wish a response, please include a self-addressed, stamped envelope.

Sol Libes
POB 1192
Mountainside, NJ 07092

I-Protect™ *for eye protection*

The only screen shield made with lead to stop x-rays from computer VDT's!

Fact: Current Federal Regulations permit computer terminals, at a distance of 6 cm. from the screen, to emit .5 millirads x-ray radiation per hour ...the old black & white TV standard.

Fact: Computed on a 35 hour work week, that can be the equivalent of a chest x-ray every 12 days, (or 30 chest x-rays each year). A single chest x-ray is 30 millirads ...and radiation is cumulative.

Fact: The **I-Protect™ Screen Shield,** a slightly tinted sheet of leaded acrylic, gives 100% protection from x-rays and most u.v. radiation.

You and your fellow workers may be joining the growing number of computer users complaining of eye fatique and other problems that seem to be caused by video display terminals used in word processors, stock reporting machines, home computers and video games. If the increase in health problems related to the extended use of VDT's concerns you, LSI offers the solution.

Developed by a physician who was troubled by the amount of radiation his son was absorbing from their home computer, **I-Protect** is made from leaded hi-impact acrylic, similar to that used to shield x-ray machines and protect workers in experimental laboratories.

I-Protect is available from Langley-St. Clair, a leader in video enhancement systems for the computer industry. It has the lead equivalency of 0.15mm, is slightly tinted to increase contrast and effectively prevents 100% of the x-rays and most of the u.v. radiation from reaching you.

In a recent FDA study,* nearly 10% of the monitors tested showed x-radiation at levels above the current limits of .5 millirads per hour, or 30 chest x-rays per year. While it may be true that when sitting 6 feet from a television screen, very little radiation actually reaches the viewer, daily close work on a video computer terminal can be subjecting you to constant radiation. So, for your protection and your peace of mind, equip your computer with an **I-Protect** screen shield.

Order an I-Protect Screen Shield now... direct from LSI. Call (800) 221-7070. (Be sure to inquire about our "Anti-Flicker Slow-Phosphor" Replacement CRT Tubes for TRS 80 Microcomputers...and about our new leaded screen shield with an exclusive anti-glare polarized surface.)



I-Protect... in two sizes, complete with velcro fasteners for easy attachment to most monitor screens. 8½"x11" - **$49.95** 10"x13" - **$59.95.** Add $2.00 for shipping and handling, $3.00 for C.O.D. New York State residents, add 8.25% sales tax. Allow 2-6 weeks for delivery.

*"Evaluation of Radiation," FDA #81-8153; U.S. Dept. HEW. NIOSH #78-129, 1977; U.S. Public Law 90-602; J.E.D.E.C. Publ. 64

For technical information and for West Coast Distributors: (800) 382-3450

In New York state, to order call (212) 989-6876.

Langley-St.Clair Instrumentation Systems, Inc. 132 West 24th Street, New York, N.Y. 10011

Circle 470 on inquiry card.

What's New?

SYSTEMS



Desktop Unit for Business and Science

The MT500, a desktop computer with data- and word-processing capabilities for business and science applications, is a Multi-Tech Systems product. It features a full DMA (direct memory access) video display, a Z80A microprocessor, the CP/M operating system, 64K bytes of RAM (random-access read/write memory), and a single-board central processing unit with built-in S-100 expansion capabilities. The MT500 has two integral 5¼-inch disk drives with floppy-disk storage capacity of up to 900K bytes and 5¼-inch Winchester disk-storage capacity of 5 megabytes.

Optional equipment for the MT500 includes letter-quality or high-speed printers and Bell 103- or 212A-compatible modems. The price for the MT500 ranges from $4795 to $7995, depending on storage options; dealer discounts are available. Multi-Tech Systems Inc. is located at 82 Second Ave. SE, New Brighton, MN 55112, (612) 631-3550.

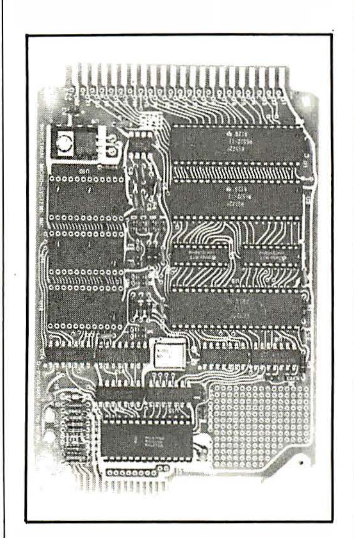
Circle 550 on inquiry card.

Development System

Sys-1 from Octagon Systems Corporation is a single-board microprocessor development system and process controller. It operates in BASIC and employs National Semiconductor's INS8073 chip with integral control BASIC interpreter. Sys-1 features 4K bytes of static RAM (random-access read/write memory), up to 4K bytes of EPROM (erasable programmable read-only memory) in 2K-byte increments, hardware-interrupt vectored in BASIC, a 2K-byte system utilities library, 24 programmable input/output (I/O) lines, 2 flags, 1 sense input, a decoded peripheral-select line, and a large breadboard area with ten 16-pin DIP (dual-inline pin) sockets. Other standard features include an EPROM programmer, a serial RS-232C I/O port that operates at data rates from 110 to 4800 bps (bits per second), and the ability to address 8K bytes of external memory.

An individual Sys-1 costs $245; OEM (original equipment manufacturer) inquiries are invited. Complete details are available from Octagon Systems Corp., 2849 West 35th Ave., Denver, CO 80211, (303) 458-1705.

Circle 551 on inquiry card.



6502 Board Is AIM-Compatible

The Model SBC651 is an AIM-compatible single-board computer from Industrial Micro-Systems. Based on the 8-bit 6502 microprocessor, the 4½-by 6½-inch SBC651 features 40 lines of parallel input/output (I/O), eight channels of 8-bit analog input, an onboard 20 mA current loop, TTL (transistor-transistor logic), and RS-232C serial I/O. Intended for controller and OEM (original equipment manufacturer) applications, the SBC651 has such standard features as four programmable 8-bit parallel ports, eight auxiliary control lines, four 16-bit counter/timers with 1-μs (microsecond) resolution, and a crystal-controlled clock that provides 1 MHz operation. The SBC651 can accommodate from 1K to 3K bytes of RAM (random-access read/write memory) and up to 10K bytes of ROM (read-only memory) and EPROM (erasable programmable ROM).

Peripheral equipment available for the SBC651 includes a device that allows Rockwell International's AIM-65 to fully emulate the SBC651 and provide low-cost development support. Another option is an EPROM burner (programmer) that is used with the AIM-65 as a program-development system. In single units, the board costs $154.50. Full product specifications are available from Industrial Micro-Systems Inc., POB 306, Plantsville, CT 06479, (203) 628-4844.

Circle 552 on inquiry card.

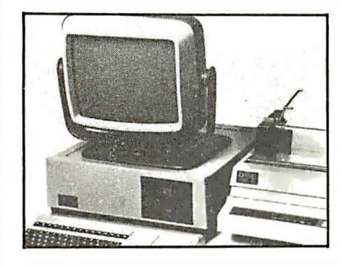
Super Computer

The Super Computer from the Mega Company is a single-board Z80A-based

unit that's guaranteed to run at 5 MHz. It features a 4K-byte system monitor in EPROM (erasable programmable read-only memory), 64K bytes of dynamic RAM (random-access read/write memory), and memory parity checking. Super Computer has a single- or double-density, single- or double-sided 5¼- or 8-inch floppy-disk controller, a hard-disk interface that connects directly to Priam Corporation's intelligent hard-disk controller, and a DMA (direct memory access) controller for the floppy disks, serial ports, and general input/output (I/O) interface. Super Computer's two serial ports operate at data rates from 150 to 19,200 bps (bits per second) and are controlled by two Z80A SIOs (serial I/Os) with drivers for full RS-232C handshaking. Other standard features include a Z80A-based counter/timer circuit, sockets for expandability, and CP/M and MP/M operating system compatibility.

Optional equipment for Super Computer includes two 8-bit bidirectional parallel ports with Z80A PIO (parallel I/O), four serial ports with two SIOs and handshaking, 448K bytes of onboard dynamic RAM with a PAL (programmable array logic) chip for either fast RAM disk or bank-switching for multiuser applications under MP/M, and a 9511A mathematics processor. The basic Super Computer system costs $1099. A full system, including the 9511A, costs $2199. Dealer inquiries and purchase orders will be accepted by the Mega Co., 2318 South Park St., Madison, WI 53713, (608) 255-7400.

Circle 553 on inquiry card.



Basis for Expansion

The Basis 200 series of modular microcomputers offers true upward expandability, because the same bus structure supports either 8- or 16-bit plug-in processors. At this time, two models are available: Basis 208 and Basis 216. The 8-bit Basis 208 features the Z80B processor, a 6-MHz clock, and the CP/M operating system. Its minimum configuration has 128K bytes of RAM (random-access read/write memory) expandable to more than 1 megabyte, dual 5¼-inch floppy-disk drives, an 8-bit parallel printer interface, a serial RS-232C interface, and a 10-slot card cage with room for additional memory, high-resolution graphics, and other equipment.

The Basis 216 is currently offered equipped with the Z8001 processor, but the 68000 and others are in development. This 16-bit machine features Microsoft's Xenix operating system and the ability to support up to 16 workstations for multitasking and multiuser environments. Approximate prices are $6000 for the Basis 208 and $9000 for the Basis 216. Further information is available from Basis Inc., 23116 Summit Rd., Los Gatos, CA 95030, (408) 438-5804.

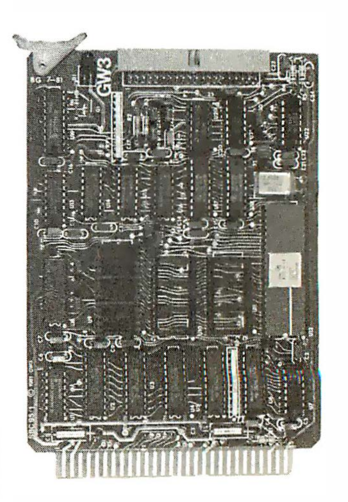
Circle 554 on inquiry card.

Multiuser, Multitasking Microcomputer

The SB-80/4 microcomputer from Colonial Data Services allows up to four users to share floppy-disk and hard-disk storage, while maintaining separate 4-MHz Z80A microprocessors with 64K bytes of RAM (random-access read/write memory) for each user. This is accomplished by placing all four computers on a single printed-circuit board, connected to a master Z80A multiuser input/output (I/O) controller. The system is CP/M compatible, uses 5¼- or 8-inch floppy disks, supports a 10- to 104-megabyte hard disk, takes up to 320K bytes of 200-nanosecond dynamic RAM, and has four Centronics-type parallel ports and six serial ports, two programmable real-time clocks, a switching power supply (115V 60 Hz or 220V 50Hz), and a 50-pin expansion connector. The system is designed to run business software under the CP/M operating system. The multiuser supervisor allows simultaneous users to share the same database and off-line memory.

For more information on the SB-80/4, contact Colonial Data Services Corp., 105 Sanford St., Hamden, CT 06514, (203) 288-2524.

Circle 555 on inquiry card.



TMS9995-based Computer

The SBC 95/1 is an STD bus single-board computer using Texas Instruments' TMS9995 processor, which is fully object-code-compatible with the TMS990 and 9900 families. The board has two independently configurable asynchronous communications ports for RS-232C and RS-422 interfaces. Also provided are a 5-bit parallel output port, an 8-bit input port, and two software-selectable memory maps. Capable of operating as a stand-alone unit, the 16-bit SBC 95/1 can be equipped with up to 16K bytes of onboard EPROM (erasable programmable read-only memory) and up to 4K bytes of RAM (random-access read/write memory).

One option available for the SBC 95/1 is Eyring Research Institute's PDOS program development tool, which consists of a real-time multitasking, multiuser DOS (disk operating system), and PDOS BASIC. Floppy-, minifloppy-, and hard-disk storage options are supported. In lots of one to nine, the SBC 95/1 costs $349. An evaluation kit that includes 4K bytes of RAM, an EPROM debugging monitor, connection hardware, and documentation can be purchased for $624. Contact GW3, 7239 Belinger Court, Springfield, VA 22150, (703) 451-2043.
Circle 556 on inquiry card.



Versatile System

Thomas Engineering Company has introduced the TEC MZ-80, a microprocessor-based computer system suitable for communications, word processing, and small-business applications. Built upon Intel's Multibus architecture, the MZ-80 is configured around separate processor, memory, input/output (I/O), and DMA (direct memory access) disk-controller boards that mount on the chassis with four or eight slots. The processor board contains a 6-MHz Z80B microprocessor, 32K bytes of 150-ns (nanosecond) dynamic RAM (random-access read/write memory), 4K bytes of ROM (read-only memory) or EPROM (erasable programmable ROM) control memory, a 30-millisecond timer, and a serial I/O port. Each additional memory board provides the MZ-80 with 32K bytes of 150-ns static RAM and allows bank switching. The I/O boards have eight independent RS-232C channels and are engineered with an onboard crystal-controlled clock to assure proper timing reference. The DMA disk controller can handle up to four standard single- or double-density 8-inch drives or two 3½-inch mini-floppy drives. Sector size can be as large as 8K bytes.

The list price for a typical ROM-based MZ-80 is $7435, including software license. The price for a disk-based configuration for use as a local processing system is $7330. Contact Thomas Engineering Co., Suite 106, 1040 Oak Grove Rd., Concord, CA 94518, (415) 680-8640.
Circle 557 on inquiry card.

PUBLICATIONS

Free Business Graphics Guide

A free guide to business computer-graphics software, systems, and services is available from **The Harvard Newsletter on Computer Graphics**; Stanley Klein, publisher and editor. The guide contains concise descriptions of source materials and the name, address, and telephone number of each supplier, including contact person. Information on foreign sources is also provided.

To receive your copy, contact the Biz CG Guide, **The Harvard Newsletter on Computer Graphics**, Service Department, POB 89, Sudbury, MA 01776. Your request must be made on letterhead and accompanied with a self-addressed envelope with $0.37 postage ($1.20 outside the U.S.) affixed. **The Harvard Newsletter on Computer Graphics** is published under the auspices of the Laboratory for Computer Graphics at Harvard University.
Circle 558 on inquiry card.

Power of Visicalc

Management Information Source has announced the availability of Robert Williams and Bruce Taylor's book **The Power of Visicalc**. Written in plain English, this book has seven easy-to-follow exercises that are designed to show you how to expand your applications usage of Visicorp's Visicalc program. **The Power of Visicalc** uses specific examples to illustrate the logic of each step in designing an applications program and step-by-step instructions that help you understand the basic concepts behind Visicalc function and command uses.

The Power of Visicalc is available in softcover for $9.95 from Management Information Source, 1626 North Vancouver, Portland, OR 97227, (503) 287-1462.
Circle 559 on inquiry card.



Microprocessor Software Databook

D.A.T.A. Inc. has introduced a new subscription service: **Microprocessor Software D.A.T.A.Book**. Published biannually, the **D.A.T.A.Book** is organized by general type of software package, by the microprocessor upon which it will operate, and by the manufacturer's title. The information covers language and extensions, ANSI (American National Standards Institute) standard, date of introduction, number of in-

stallations, memory and peripheral requirements, and available support. Some of the topics covered by D.A.T.A.Book are resident, cross-system, system support, and applications programs.

D.A.T.A. Inc.'s Microprocessor Software D.A.T.A.Book costs $120. Purchasing information is available from D.A.T.A. Inc., POB 26875, San Diego, CA 92126, (800) 854-7030; in California, (714) 578-7600.

Circle 560 on inquiry card.

Newsletter for Pascal Users

Pascal Market News is aimed at current and prospective Pascal language users. This bimonthly newsletter is packed with Pascal hardware and software information, commercial notices, and interviews with personalities in the news. In a recent issue, Pascal Market News explored the use of Pascal in real-time chemical analysis of blood samples at Yale–New Haven Hospital.

Subscribing to Pascal Market News entitles you to discounts on many Pascal-related books and software publications. A year's subscription costs $20 in North America. Foreign prepaid air-mail subscriptions are $29, and invoiced subscriptions are $4 higher. Order from Pascal Market News, POB 5314, Mount Carmel, CT 06518.

Circle 561 on inquiry card.

Marine Industry Journal

Floating Point is a quarterly newsletter devoted to the use of computers in the small naval-architectural or boat-design office, small shipyard or boatyard, and on board ships. Its scope covers easily accessible programs for large computers, interactive timesharing, and programmable calculators as well as personal and small-business computers. Floating Point is produced by the Bay Area Marine Institute, a nonprofit educational corporation engaged in apprenticeship training, continuing education, research, and computer software development for the marine industry.

Subscriptions to Floating Point cost $5 per year. For a sample issue and further subscription information, contact Bay Area Marine Institute, Pier 66, San Francisco, CA 94107, (415) 552-4500.

Circle 562 on inquiry card.

Database Management Tool Explained

A free 12-page brochure describing Micro Data Base Systems' MDBS III microcomputer database-management application development tool is available from ISE–USA. MDBS III innovations, advantages, features, and capabilities, including its flexible query system, are described. Typical applications are discussed, and a company profile is provided. Obtain your copy from ISE–USA, 350 West Sagamore Parkway, West Lafayette, IN 47906, (317) 463-2581.

Circle 563 on inquiry card.

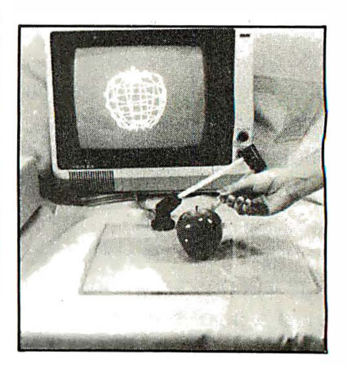
Consumer Newsletter Tests TRS-80 Software

Software Review is a bimonthly newsletter that tests and evaluates programs for Radio Shack TRS-80 Model I and III users. Software Review reports on a program's performance, advantages, and limitations from the user's point of view to help consumers select the products that are best for them. In each issue a wide range of materials are evaluated, including games, business programs, operating systems, utilities, educational programs, and languages. One special feature, the Bug Killer column, provides advice, operating and programming tips, short cuts, fixes, hardware reviews, modifications, and so on.

For a sample copy of the Software Review, send a self-addressed envelope with $0.37 postage to Software Review, 92 Washington Ave., Cedarhurst, NY 11516. Retailers or computer clubs interested in selling the Software Review can call (516) 374-5193.

Circle 564 on inquiry card.

PERIPHERALS



Three-Dimensional Graphics Tablet

Micro Control Systems and Penguin Software have joined together to create Space Tablet, a hardware/software three-dimensional graphics input device for the Apple II. Space Tablet's hardware is made up of a clear 16- by 13-inch two-dimensional workspace and an arm with an elbow that enables it to swivel on the two-dimensional space or rotate above the tablet. Information on the position of the tip of the arm is converted by the computer to X,Y,Z coordinates, making it possible to trace three-dimensional objects, both real and imaginary. The tablet, which connects to the Apple by means of the paddle port, also has two buttons for additional inputs.

Space Tablet's software allows it to be used as a standard two-dimensional tablet or in three dimensions. Its two-dimensional programs include the high-resolution drawing, text, and shape routines available in the Apple Tablet and paddle/joystick ver-

sions of that package. The three-dimensional programs expand the input from a choice of coordinates or two-dimensional panels to three-dimensional locations. You can recall any three-dimensional object from memory at any time, display it on the Apple's screen, rotate it on any axis, and scale and edit it.

The Space Tablet costs $475. A slightly different version is produced for the IBM Personal Computer. It costs $595. Contact Micro Control Systems, 230 Hartford Turnpike, Vernon, CT 06066, (203) 643-4897.

Circle 565 on inquiry card.

TRS-80 Data Acquisition and Control

The 8882 data-acquisition and control system from Starbuck Data Company is designed for Radio Shack's TRS-80 Models I and III. The device has eight digital inputs, eight digital outputs, eight 0- to 5-volt analog inputs, two analog joystick ports; all inputs and outputs are fully protected. Supplied software permits high-speed data acquisition of up to 4000 points per second and up to 30 points per second for low-speed acquisition in the interrupt mode. In the interrupt mode, the 8882 allows all data acquisition and control to be timeshared with normal TRS-80 use.

The 8882 data-acquisition and control system for the TRS-80 costs less than $200, including software. Complete product and purchasing information is available from Starbuck Data Co., POB 24, Newton Lower Falls, MA 02162, (617) 237-7695.

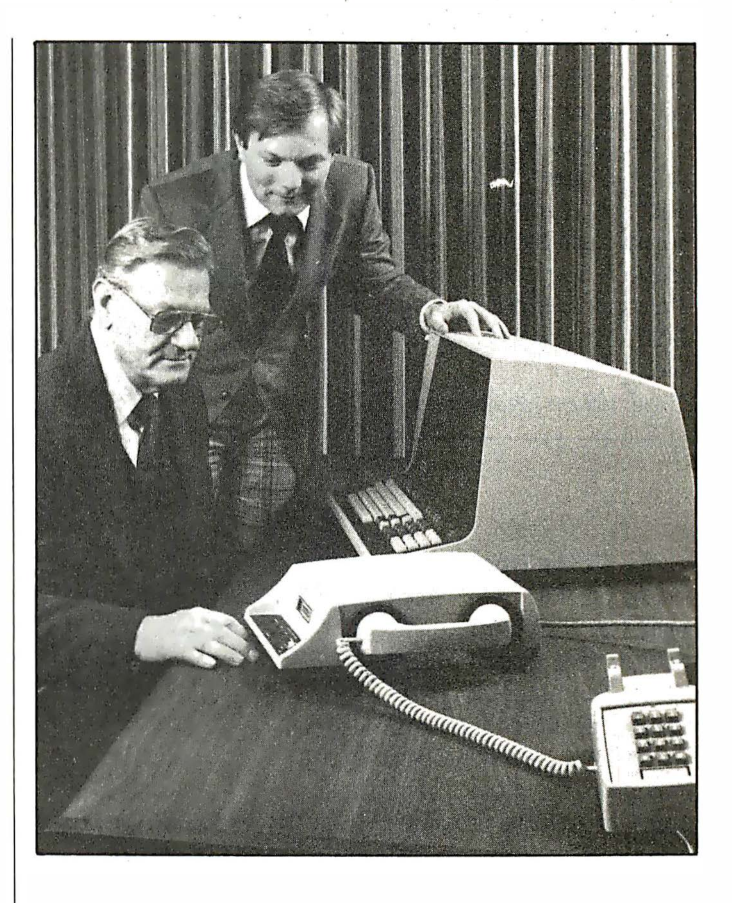
Circle 566 on inquiry card.

Apple PROM Development System

A PROM (programmable read-only memory) development system for the Apple II is available from Vista Computer Company. This system simulates PROM in RAM (random-access read/write memory), allowing new code to be tested and modified within the computer before the PROM is burned in. Supplied with a disk-based, menu-driven program-development monitor, the system has onboard memory that can be directly loaded from assembler or disk. Other standard features include a data and address interface for operator location and control.

The Vista Computer PROM development system simulates and programs most standard PROMs, including 2K- and 4K-byte EPROMs (erasable PROMs) such as 2708, 2716, and 2532 types. The system costs $495. Further details are available from Vista Computer Co., 1317 East Edinger, Santa Ana, CA 92705, (714) 953-0523.

Circle 567 on inquiry card.



Acoustic Data Coupler

The Anderson Jacobson AJ 1233 acoustic data coupler is capable of communicating with Bell 212-type modems. The AJ 1233 is an orginate-only full-duplex acoustic coupler with switch-selectable data rates of 1200 bps (bits per second) for synchronous or asynchronous communications and from 0 to 450 bps for asynchronous communications. It can be used either as an acoustic coupler or as a modem, and it can communicate with VA 3400 and AJ 1200 series modems and in Bell 103 or 113 modes.

The microprocessor-controlled, Federal Communications Commission-approved AJ 1233 costs $995. Complete details are available from Anderson Jacobson Inc., 521 Charcot Ave., San Jose, CA 95131, (408) 263-8520.

Circle 568 on inquiry card.

Analog I/O Interface

International Aerospace Products' Model ADA 8/4 AP analog input/output (I/O) interface board is designed for the Apple II. It's equipped with eight A/D (analog-to-digital) input channels, four D/A (digital-to-analog) output channels, screw-activated terminal strips for I/O connections, voltage-follower buffers on A/D inputs, V_{REF} output for ratiometric transducers, and buffers on D/A outputs. It's compatible with any language, such

as BASIC, that allows direct addressing of specific memory locations.

The ADA 8/4 AP plugs in any Apple II I/O slot except slot 0. Complete specifications are available upon request from International Aerospace Products Inc., POB 166, White Marsh, VA 23183.

Circle 569 on inquiry card.

Color Port

The Color Port from Maple Leaf Systems gives your Radio Shack TRS-80 Color Computer powerful input/output capabilities. The plug-in cartridge Color Port gives the Color Computer two fully programmable 8-bit bidirectional parallel ports with full handshaking. It supports full interrupt capability and computer voltage and logic control lines are brought out to the standard edge connector. Additionally, the cartridge has a socket for 2K bytes of RAM (random-access read/write memory) or EPROM (erasable programmable read-only memory).

Optional equipment for the Color Port includes 2K-byte RAMs and 2K-byte EPROMs. With documentation, the Color Port cartridge without memory costs $129.95. The optional RAM is available for $19.95, and the EPROM costs $12.95. All can be purchased from Maple Leaf Systems, POB 2190, Station C, Downsview, Ontario M2N 2S9, Canada.

Circle 570 on inquiry card.



Glitch Sentinel Has Built-In Printer

The Model GS-2 Glitch Sentinel power-line monitor from Billings McEachern diagnoses power problems for microcomputers, disk drives, and other sensitive electronic equipment. The Sentinel checks for power failures, low and high line voltages, spikes, voltage drops, high-frequency noise, and high and low line frequencies. Built-in features include a clock/calendar, a user-enabled audible alarm, latched LEDs (light-emitting diodes) for each alarm type, and a printer that prints alarm messages in English.

In addition to the Model GS-2, Billings McEachern offers the GS-1 and the GS-3 Glitch Sentry power-line monitors. The GS-1 is similar to the GS-2, but it does not have the printer, clock/calendar, and the line-frequency monitoring capabilities. The GS-3 is designed for three-phase power monitoring.

In single units, the Model GS-2 Glitch Sentinel and the Model GS-3 cost $900; in lots of two to ten, the price is $750. A single GS-1 costs $300, and two to ten units are available for $250 each. Order directly from the manufacturer, Billings McEachern Inc., Suite 106, 333 Cobalt Way, Sunnyvale, CA 94086, (408) 746-0830.

Circle 571 on inquiry card.

Apple Time II

Time II, an Applied Engineering product, is a real-time clock/calendar for the Apple II computer. Time II tells time in hours, minutes, and seconds with program-selectable 24-hour military or 12-hour (with a.m. and p.m. indication) formats. It tells you the date with year, month, date, day of week, and leap year information. Standard features include rapid date and time setting, crystal-control for 0.0005% accuracy, latched input/output ports for easy PEEK and POKE BASIC programming, and an onboard battery backup that provides power-off operation for more than four months. With Time II, you can call up schedules, time events, and date listings and other printouts because its DIP-(dual-inline package) switch-selectable interrupts permit foreground and background operation of two programs simultaneously.

Time II is supplied with a 16-sector DOS 3.3 disk with Time II programs and a 23-page operating manual that contains many example programs to use with your Apple II. The price is $129. Contact Applied Engineering, POB 470301, Dallas, TX 75247, (214) 492-2027.

Circle 572 on inquiry card.

SOFTWARE

Stock and Commodities Messenger

George Arndt's Investors' Micro Messenger (IMM) is made up of a group of investors who pool their expertise to develop stock- and commodities-management software for the Apple II. As an IMM

member, you receive annually four packages containing floppy disk-based software, updated commodity database, a detailed instruction book written in nontechnical language, complete documentation and reports, and graphics software that allows you to see buy-and-sell calls with daily open, high, low, and close. Opportunities to purchase technical trade books are also offered.

The IMM membership fee is $995 for the first year and $350 for the second year. Members receive $100 for each program donated to IMM. Complete details are available from George Arndt, CTA, Investors' Micro Messenger, POB 319, Harvard, MA 01451, (617) 456-8830.

Circle 573 on inquiry card.

Atari BASIC Tutorials

Santa Cruz Educational Software's Tricky Tutorials are designed to help sharpen your Atari BASIC programming skills. Each tutorial in the six-disk package consists of a discussion in plain language and examples already entered and running. The topics covered are Display Lists, Horizontal and Vertical Scrolling, Page Flipping, Basics of Animation, Player Missile Graphics, and Sounds and Music.

Tricky Tutorials are available on tape or disk in a single package for $99.95 plus $3 for shipping and handling. They require 16K- to 32K-byte tape-based Ataris or 24K- or 32K-byte Ataris with disk drives. Order Tricky Tutorials from Santa Cruz Educational Software, 5425 Jigger Dr., Soquel, CA 95073, (408) 476-4901.

Circle 574 on inquiry card.

Strategy Game

Automated Simulations' Ricochet is a strategy game combined with fast-action graphics. It can be played with another player or any of four different computer opponents. Here's how it works: players maneuver blocks to set up a shot at the opposing goal and to protect their own goal. Each contestant has two launchers to fire. Shots ricochet off the blocks, earning points for each hit plus bonus points for hitting the opponent's goal. Before victory can be claimed, a player must win two of three (or three of five) games.

Ricochet is available on cassette for 16K-byte Atari 400/800s equipped with the BASIC ROM (read-only memory) cartridge and 16K-byte Level II TRS-80s. On disk, the game can be enjoyed on 32K-byte Atari 400/800s, 32K TRS-80s with the TRSDOS operating system, and 48K-byte Apples with Applesoft in ROM. The suggested retail price is $19.95. Contact Automated Simulations, POB 4247, Mountain View, CA 94040.

Circle 575 on inquiry card.

Solar Design Programs

Version 2.0 of Solarsoft's Sunpas, Sunop, and Tswing interactive solar-analysis programs for 48K-byte Apple II Plus computers is now available. Given both the solar input and the load on the building, Sunpas and Sunop estimate the yearly auxiliary heating requirements of a passive solar building. Both programs are based on Los Alamos National Laboratory's Solar Load Ratio Method, which is described in volume two of the **Passive Solar Design Handbook** (available for $30.50 from National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161). With documentation, Sunpas and Sunop cost $250 each or $400, if purchased together.

Tswing is a nodal-analysis thermal-simulation program that helps predict temperature swings in a building. It is useful for sizing mass and glazing areas to prevent overheating. Tswing makes extensive use of graphs to supplement hard-copy printouts of data. Provided with Tswing is Solgain, a clear-day solar-insolation routine to calculate incident and transmitted hourly solar gains. Tswing costs $395, including a 60-page manual.

Sunpas, Sunop, and Tswing can be purchased as a three-program package for $700. Yearly subscriptions to an updating service are available for $75, and users manuals without software may be obtained for $25. Get additional details on these programs from Solarsoft Inc., POB 124, Snowmass, CO 81654, (303) 927-4411.

Circle 576 on inquiry card.

PILOT for CP/M

Owners of CP/M-based computers can now run the Nevada PILOT language, thanks to Ellis Computing. A string-oriented language, Nevada PILOT is designed for interactive applications such as data entry, programmed instruction, and testing. Among its many features are an integrated full-screen text editor and the ability to drive video-tape recorders, voice-response units, and other optional equipment. With Nevada PILOT, someone with no prior computer experience can develop dialog programs in an hour or so. Nevada PILOT meets all PILOT-73 standards.

Nevada PILOT requires 32K bytes of RAM (random-access read/write memory), one disk drive, a video display and keyboard. It will run on TRS-80, North Star, Superbrain, Micropolis, Vector, Softcard-equipped Apples, and many other CP/M-based systems. Nevada PILOT costs $149.95, which includes a floppy disk and a manual, and is available from Ellis Computing, 600 41st Ave., San Francisco, CA 94121, (415) 751-1522.

Circle 577 on inquiry card.

What's New?

Flexible Changes

The Flex 9.0 DOS (disk operating system) for Radio Shack's TRS-80 Color Computer is available from Technical Systems Consultants (TSC), 111 Providence Rd., Chapel Hill, NC 27514. Occasionally, changes to TSC-supplied utility programs are required to avoid memory conflicts with the BASIC ROMs (read-only memories). These changes and an implementation guide can be obtained from South East Media, POB 794, Chattanooga, TN 37443.
Circle 578 on inquiry card.

Wiremaster 4.02

Afterthought Engineering has released version 4.02 of its Wiremaster software tool for the design, layout, and construction of electronics hardware. Wiremaster generates network maps, wire lists, cross-references, and checklists. It can handle large industrial jobs as well as small prototypes and hobby projects. Version 4.02 enhancements include location accuracy of 0.001 inch, provisions for twisted-pair and coaxial wiring, and input language expansions that handle special components such as connectors.

Wiremaster version 4.02 costs $200; computer club members are eligible for a 50% discount. Updates to earlier versions are priced at $25. Complete details can be obtained from Afterthought Engineering, 7266 Courtney Dr., San Diego, CA 92111, (714) 279-2868.
Circle 579 on inquiry card.

TRS-80 Game System

The Adventure System has all the necessary ingredients you need to cook up adventure-type games on your Radio Shack TRS-80 Model I or III. Offered by The Alternate Source, the Adventure System consists of an editor that compiles a command language into an adventure database and a driver program that executes the database. A manual documenting the Adventure Language syntax and a complete analysis of a small adventure is provided. Two full adventures are also supplied with the System.

The Adventure System requires a 48K-byte TRS-80 Model I or III with disk drives. It is available on formatted disks for $39.95. Purchase orders are being fulfilled by The Alternate Source, 1806 Ada St., Lansing, MI 48910, (517) 487-3358.
Circle 580 on inquiry card.

Disk Recovery System

DPatch 1.3 is a CP/M- and MP/M-based disk recovery and reliability system from Advanced Micro Techniques. It gives you the ability to recover files that contain input/output errors and to regain the use of disks that have error tracks. With DPatch, files that have been erased from the disk directory may be recovered. Additionally, you can extract data from files that are no longer readable under normal circumstances. Damaged or unreadable disks can be returned to normal using DPatch's Surface Analysis, which analyzes and locks out damaged areas.

DPatch is distributed in most popular disk formats and has a suggested retail price of $195. The manufacturer invites dealer and OEM (original equipment manufacturer) inquiries. Complete specifications are available from Advanced Micro Techniques, Suite 209, 1291 East Hillsdale Blvd., Foster City, CA 94404, (415) 349-9336.
Circle 581 on inquiry card.

Bigbug Squashes Debugging Delays

Future Project Corporation has developed Bigbug, a Z80 monitor for controlling Radio Shack TRS-80 Model I Level II assembly-language programming. The device features a ROM- (read-only memory) based monitor that doesn't need a backup, direct access of input/output, a hexadecimal calculator, built-in RS-232C driver software, up to eight user-selectable breakpoints,and the ability to produce hardcopy printouts for debugging history. Bigbug can be treated as a subroutine from your programs, and its hardware can accept your own EPROM (erasable programmable ROM), which can save you loading time. Other features include 3K bytes of memory that permit a target program to be resident anywhere in memory.

Bigbug costs $75. Further details are available from Future Project Corp., POB 11, Hawleyville, CT 06440, (203) 775-3062.
Circle 582 on inquiry card.

Superfile System

FYI Inc. has introduced Superfile, an indexing and file-retrieval system for text entries of any size. The system can handle more than 7000 entries per database on 8-inch single-density disks or 2500 entries per database on 80K-byte 5¼-inch disks. Superfile can search as many as 100 entries per second, and up to 65 keywords can be combined with AND, OR, and NOT in a single search. Superfile lets you direct output to the screen, printer, or disk, and it does not limit the amount of text per entry or the number of data disks per database. Additionally, Superfile can access up to 16 floppy- or hard-disk drives.

Superfile runs under the CP/M operating system on Z80-based processors. Available on 8-inch and most 5¼-inch disks, Superfile costs $195, which includes a demonstration database, installation pro-

gram, and a user's manual. Orders for the Superfile indexing and retrieval system are being accepted by FYI Inc., POB 10998 #615a, Austin, TX 78766, (512) 258-6310.

Circle 583 on inquiry card.

Statistics Package

Questionnaire Service Company's Statistical Package for Microcomputers (SP-Micro) is based on SPSS Inc.'s Statistical Package for Social Sciences. It features variable and value labels, long variable names, missing values, and English-language error messages. Built-in print routines are programmed for an 80-column printer and include controls for page length. Among the procedures implemented in SP-Micro are frequency distribution with optional histogram, cross-tabs (includes chi-square), Pearson correlation with an optional covariance table, and multiple regression with block-wise or stepwise inclusion levels.

SP-Micro requires a TRS-80 Model II or a North Star computer, the CP/M operating system, and CBASIC2. The manufacturer recommends a minimum of 48K bytes of memory and two disk drives. SP-Micro costs $250, including a manual, which is available separately for $5. SP-Micro can be ordered from the Questionnaire Service Co., POB 23056, Lansing, MI 48909.

Circle 584 on inquiry card.

MISCELLANEOUS



Micromonitor

MK Enterprises' Micromonitor MX2100 Teleprocessor is a 3- by 5- by 1½-inch device that can connect your microcomputer to the Bell Telephone Network. The Micromonitor is a DTMF (dual-tone multifrequency) transceiver/coupler outfitted with parallel input/output, two 600-ohm audio channels, ring and off-hook signaling circuitry, a retriggerable circuit that signals the presence of a conversation, and circuitry that monitors the status of the telephone trunk (i.e., dial tone, ringing, busy, etc.). Two onboard optoisolators can control your equipment by means of Touch-Tone (a registered trademark of AT&T) commands. The Micromonitor's Touch-Tone transmitter allows outward dialing in PABX (private automatic branch exchange) applications, including automatic redial and speed dialing, while its companion Touch-Tone receiver permits end-to-end signaling for remote data entry. When used with a microprocessor or an intelligent controller, the Micromonitor is capable of performing sophisticated functions such as telephone call accounting, information retrieval, radio-telephone paging, and remote security monitoring.

Certified by the Federal Communications Commission, the Micromonitor is compatible with Apple, STD bus, and many single-board computers. It costs $495, including a manual. Additional operating specifications are available from MK Enterprises, 8911 Norwick Rd., POB 29654, Richmond, VA 23229, (804) 740-8380.

Circle 585 on inquiry card.

Monolithic Dual 8-Bit D/A Converter

Analog Devices has introduced the AD7528, a monolithic dual 8-bit D/A (digital-to-analog) converter. With both converters on the same chip, and with the use of a common data bus to load either D/A register, Analog Devices engineered the dual D/A converter in a 20-pin DIP (dual-inline package). The AD7528 has onboard data latches and a microprocessor interface. Each of the AD7528's D/A converters has its own reference input, which eliminates the need to test and select D/A converters in most applications where precise matching is required.

The AD7528 monolithic dual 8-bit D/A converter is available in various grades for industrial and military applications. Complete grade descriptions and product information can be obtained from Analog Devices, Route 1 Industrial Park, POB 280, Norwood, MA 02062.

Circle 586 on inquiry card.

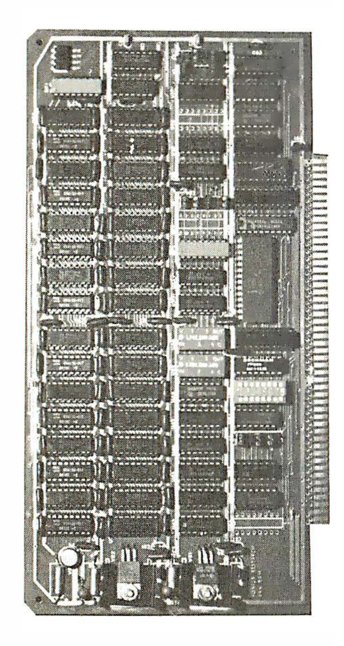
Data Line Tester

Warren Instrotech's portable W-DLT (data-line tester) can identify seven commonly used RS-232C data lines and show the likely cause of a connection problem. It's provided with a switch that enables it to function as a Null Modem, which is used to interconnect two terminals, modems, or com-

puters without rewiring cables. In the Null Modem mode, any standard device can communicate with other devices by means of one standard type of cable.

The W-DLT comes with a full set of instructions and a one-year warranty. It costs $59.95; quantity and dealer discounts are available. Contact Warren Instrotech Ltd., POB 4500, Ogdensburg, NY 13669; in Canada, POB 5739, Station F, Ottawa, Ontario K2C 3M1, (613) 728-9120.

Circle 587 on inquiry card.



S-100-based Dynamic RAM Board

Sonics Research Corporation recently introduced a low-cost S-100-based 64K-byte bank-selectable dynamic RAM (random-access read/write memory) board. The board provides continuous memory refresh during system resets and long wait states, true bank-selectability in 16K-byte levels, switch-selectable port assignments, and compatibility with most Z80-based S-100 systems, including Cromemco, North Star, Vector Graphic, TDL, and SD Systems. Other features include the ability to assign 16K-byte banks to any of four locations within the 64K-byte address space and the ability to enable and disable 16K-byte banks under software control. Power requirements are 6½ watts.

The Sonics Research 64K-byte dynamic memory board has a suggested retail price of $450, assembled and tested. Further information is available from Sonics Research Corp., Suite 505, 1500 Northwest 62nd St., Fort Lauderdale, FL 33309, (305) 776-7177.

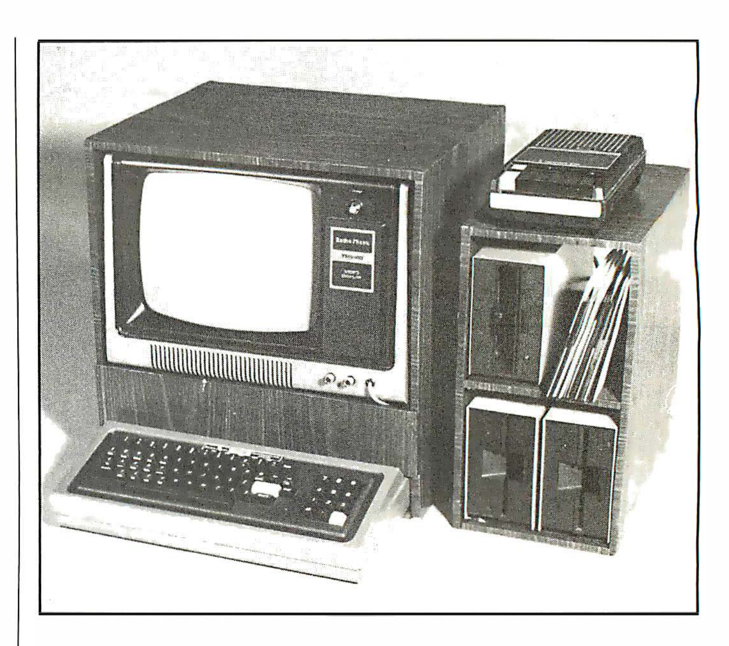
Circle 588 on inquiry card.

Hug Your Office Equipment

The Huggy System can protect your office equipment from theft. Conventional tools cannot remove the Huggy System's "Tufnut," yet removal does not require special tools.

The Huggy System number 101 will secure a single piece of equipment. It's available in kit form for $10.95. The master Huggy System service kit, number 1020, secures up to 12 machines and is available for $89.50. Contact the Huggy System, 2660 West Chester Pike, Broomall, PA 19008, (800) 345-1280; in Pennsylvania, (215) 359-1004.

Circle 589 on inquiry card.



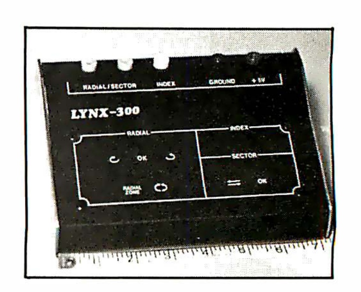
Hide Your Cables and Wires

Designatron's Organizer places your Radio Shack TRS-80 Model I's components into a single desktop package, hiding the wires and cables. The Organizer is made up of two wood-grain cabinets. The first cabinet, which has a removable front panel for easy rebooting, holds the monitor, expansion interface, power supplies, line filters, power strip, and fan. The second cabinet can hold up to four disk drives, a tape recorder, fan, floppy disks, and cassettes.

The Organizer costs $87.50, plus $8.75 shipping and handling. Orders are being accepted by Designatron, 2794 Hume Rd., Malibu, CA 90265, (213) 456-9023.

Circle 590 on inquiry card.

Align Disk Drives Without a Scope



The Lynx-300 from Lynx Design & Technology lets your field-service personnel make all necessary floppy-disk alignment adjustments without an oscilloscope. The Lynx-300 comes with a color-coded set of probes, which attach directly to a drive's printed-circuit board, and with a series of LEDs (light-emitting diodes) to indicate the proper settings for radial and index/sector adjustments and to indicate if the adjustment is not within specifications. The Lynx-300 is powered directly from the drive.

The Lynx-300 comes with a zippered leatherette case and is priced at $394

(U.S. funds) and $475 (Canadian funds). For complete specifications, contact Lynx Design & Technology Inc., 3880 Chesswood Dr., Downsview, Ontario M3J 2W6, Canada, (416) 638-4875.
Circle 591 on inquiry card.



Products for HP Users

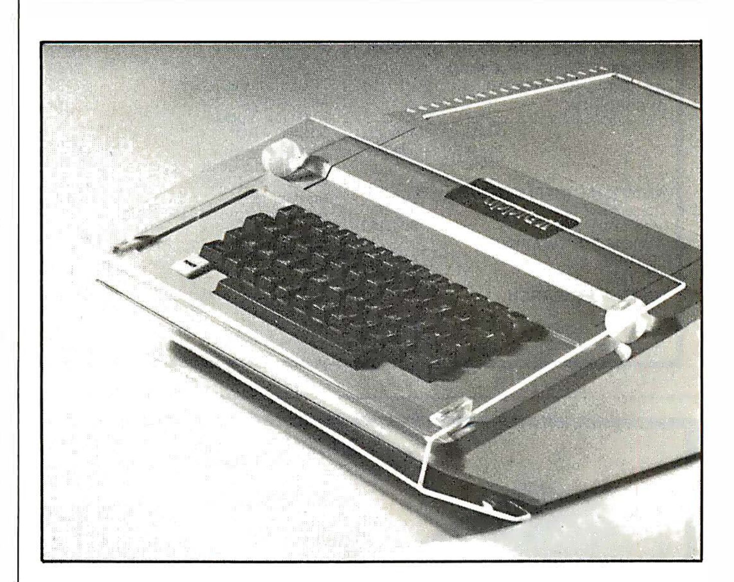
The Hand Held Products Division of F.M. Weaver Associates produces a wide range of products and services for HP (Hewlett-Packard) users. The HHP-16K EPROM (erasable programmable read-only memory) is one such product. It gives HP-41C and -41CV calculator users cost-effective application program storage. The HHP-16K, basically a ROM (read-only memory) emulator, can hold 4K- or 8K-byte programs for storage, or it can hold up to 16K-byte programs, depending on the selection of EPROMs. The HHP-16K costs $241.

Other products offered include the HHP-41DS user development system and the BURN software program for the HP-85 SDS-II computer. The BURN program is available for a one-time lease fee of $495. The Hand Held Products Division will convert to EPROM storage programs stored on magnetic cards or Hewlett-Packard development system tape or disk. The price for this service ranges from $50 for a 4K-byte program to $100 for a 16K-byte program. For more information, contact F.M. Weaver Associates Inc., Hand Held Products Division, 6201 Fair Valley Dr., Charlotte, NC 28211, (704) 377-3841.
Circle 592 on inquiry card.

Floppy-Disk Controllers

Western Digital Corporation has introduced the FD176X family of 5¼-inch floppy-disk controllers that provides all the features of its industry-standard FD179X family. The FD176X family operates at 1 MHz and is fully compatible with existing minifloppy-disk designs using the FD179X standard. Aimed at soft-sectored systems equipped with automatic track seek with verification and providing DMA (direct memory access) or programmed data-bus transfers, the FD176X family supports single- or multiple-sector reads or writes with automatic sector search in both modes, or it can read and write an entire track. Currently, Western Digital has four members in the family: the FD1761, -63, -65, and -67, which cover all combinations of single- or double-density, true or inverted data bus, and single- or double-sided drives. The FD176X family can be used with single-density IBM 3740 or double-density IBM System/34 formats.

In production quantities, the FD176X family is available in ceramic or plastic packages for 40-pin devices for $36 and $25.30, respectively. Full product information and applications assistance can be obtained from Western Digital Corp., 2445 McCabe Way, Irvine, CA 92714, (714) 557-3550.
Circle 593 on inquiry card.



Keyboard Guard

Plexa-Lok from Last Electronics guards your Apple II keyboard from contaminants and curious fingers. Made of clear 0.080-inch-thick acrylic, Plexa-Lok slips up and over the keyboard, then snaps into position. It does not affect air circulation.

Plexa-Lok comes with a 60-day warranty and costs $19.95, postpaid. Contact Last Electronics, POB 1300, San Andreas, CA 95249, (209) 754-1800.
Circle 594 on inquiry card.

Where Do New Products Items Come From?
The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first-in first-out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

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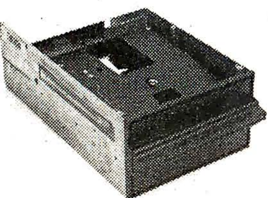
	Disk with Manual / Manual Only
ARTIFICIAL INTELLIGENCE	
Dental (PAS-3)	$849/40
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BYROM SOFTWARE	
*BSTAM	$149
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DIGITAL RESEARCH	
CP/M	
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Micropolis	$169/25
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Spellguard	$229/25
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Pascal Z	$349/30
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SPP Only	$140/15
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Wordsearch	$179/50
String 80	$ 84/20
String 80 (Source)	$279
String Bit	$ 65
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Selector IV	$269/35
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MICRO TAX	
*Level I	$249
*Level II	$995
*Level III	$749
*Combo II + III	$1495
Microsoft 5.3	49
Run time module	
MICRO PRO®	
Wordstar	$309/60
WS Training Guide	20
WS Custom Notes	$429/na
MailMerge	$109/25
WS-Mailmerge	$419/85
Datastar	$249/60
DS Custom Notes	$429/na
Calcstar	$259/na
Supersort I	$199/40
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Basic-80	$298
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Edit-80	$ 84
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*Act 69	
*Act 86/88	$149/25
*Trans 86	$119/25
*Supercalc	$269
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*Raid	$224/35
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GL, AR, AP, PR, OE	$849/40
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*Diagnostic II	$ 84/20
*Forth	$149/30
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Supercalc	$269/NA
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Optimizer	$200/NA
CP/M-86	
Supersoft C	$500/NA
Pascal MT + 86 w/SPP	$730/NA
CBasic-86	$299/NA
SuperCalc	$369/NA
SuperSoft C Compiler	$450/NA
Wordmaster	$Call
MISCELLANEOUS	
*dBASE II	$575/50
Plan-80	$269/30
*Fabs (B-Tree)	$159/25
Ultrasort	$159/25
*Super vyx	$ 89/15
*Micro B+	
(Specify Language)	$229/20
*Mini Model	$449/50
*Spellbinder	$349/45
*Statpak	$439/40
*"The Word"	$ 75
*Lynx	$199/20
Mfg. Inventory and Control Program TI990, 300 Meg. storage required Distributed in Cobol object code Call for Info.	$20000/NA

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A

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Compatible with Northstar, Cromemco, TRS-80
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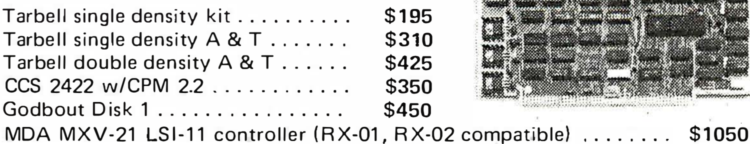
TANDON 5¼" HARD DISKS
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CCS 2810 .... $ 275
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CCS 2116 32K static .... $ 625
Godbout RAM 17 64K .... $ 675

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CCS 2710 4 SIO .... $ 325
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Tarbell single density A & T $310
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CCS 2422 w/CPM 2.2 .... $350
Godbout Disk 1 .... $450
MDA MXV-21 LSI-11 controller (RX-01, RX-02 compatible) $1050

MISCELLANEOUS
2 Disk drive enclosure .... $ 95
(fits Siemens, Shugart, Qume)
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Mini-Enclosure with power supply
1 drive .... $ 85
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DAISY WHEEL PRINTER .. $2395
45 CPS, RO. Available in KSR version.
Call for further particulars.
Ribbons: $125/case
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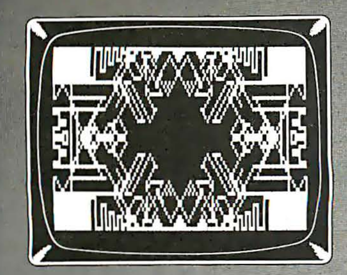
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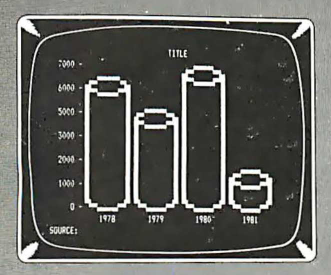
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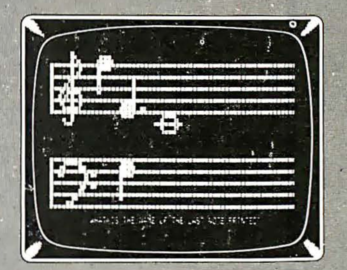
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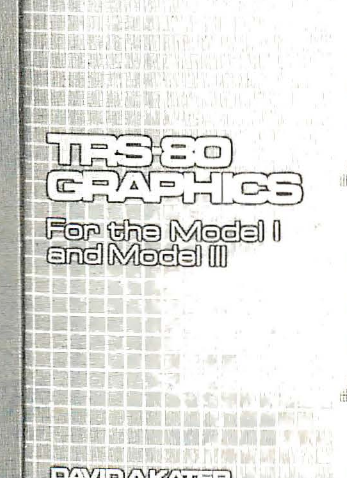


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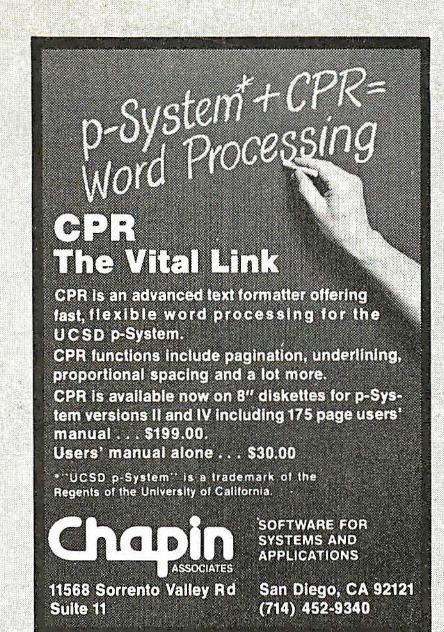
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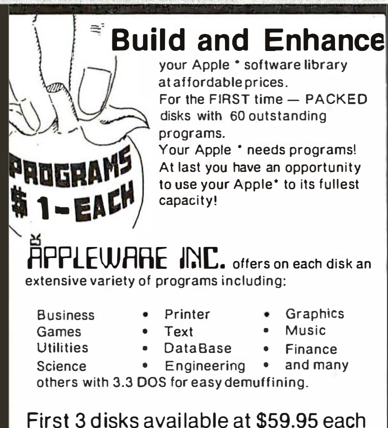
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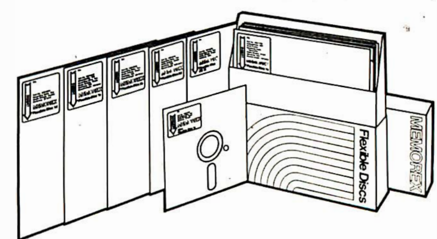








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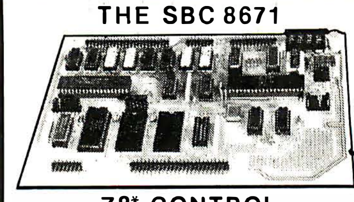
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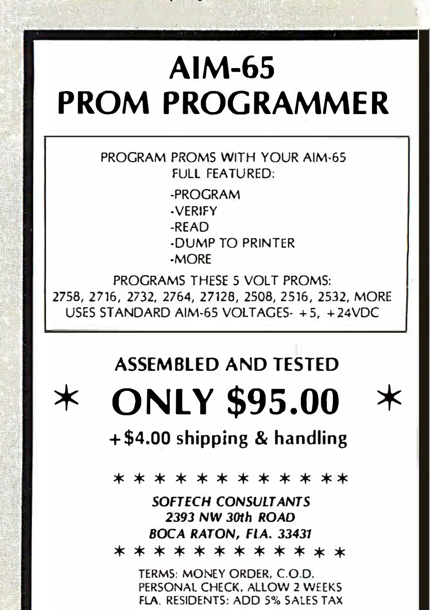
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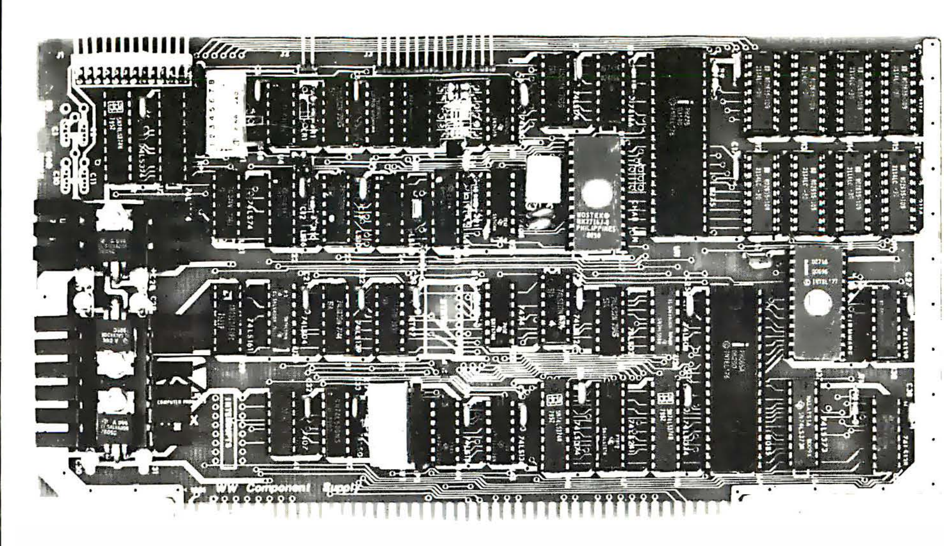


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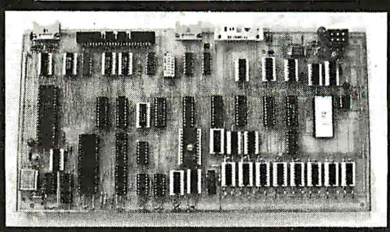
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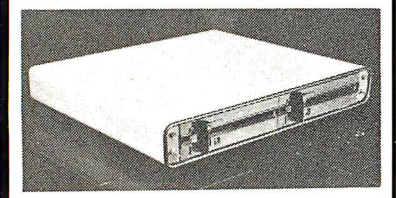
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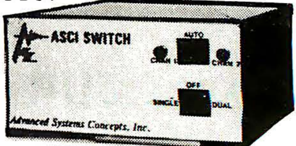
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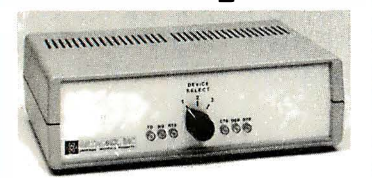
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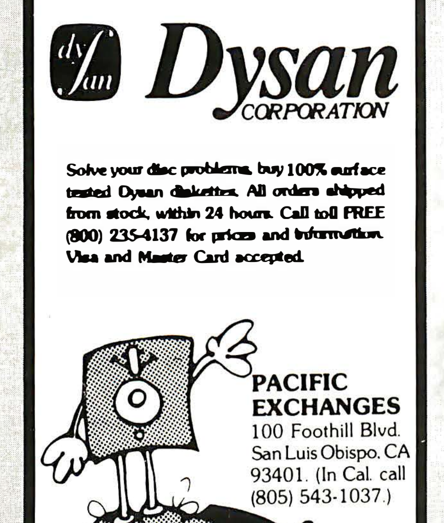
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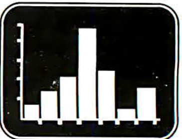
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74LS27	.24	74LS157	.75	74LS353	1.49
74LS28	.30	74LS158	.75	74LS363	1.49
74LS30	.24	74LS160	.95	74LS364	1.95
74LS32	.36	74LS161	.95	74LS365	.89
74LS33	.55	74LS162	.95	74LS366	.89
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74LS38	.35	74LS164	.95	74LS368	.69
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74LS47	.75	74LS168	1.69	74LS377	1.40
74LS48	.75	74LS169	1.69	74LS378	1.15
74LS49	.75	74LS170	1.69	74LS379	1.35
74LS51	.30	74LS173	.75	74LS385	1.89
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4021	.90	4512	.90
4022	1.10	4514	1.20
4023	.35	4515	2.20
4024	.75	4516	1.50
4025	.35	4518	1.20
4026	1.60	4519	1.20
4027	.60	4520	1.20
4028	.75	4522	1.20
4029	.90	4526	1.20
4030	.45	4527	1.90
4034	2.90	4528	1.20
4035	.85	4531	.90
4040	.90	4532	1.90
4041	1.20	4538	1.90
4042	.75	4539	1.90
4043	.75	4543	2.70
4044	.75	4555	.90
4046	.90	4556	.90
4047	.90	4581	1.90
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4053	.90		
4060	1.39	80C07	.90
4066	.75	80C95	.90
4068	.39	80C96	.90
4069	.30	80C97	.90
4070	.35	80C98	1.15

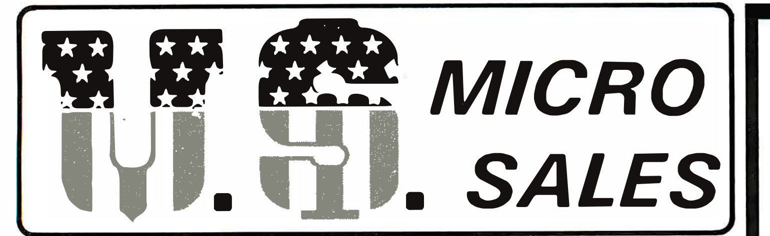
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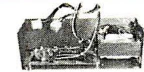


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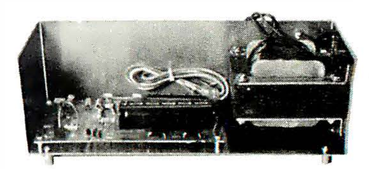


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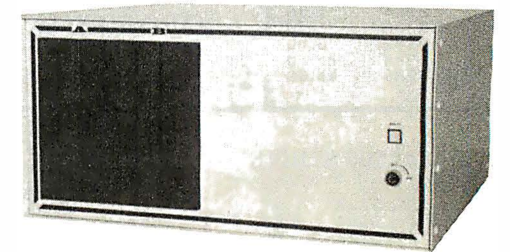
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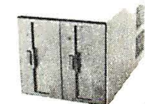
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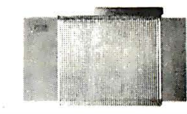
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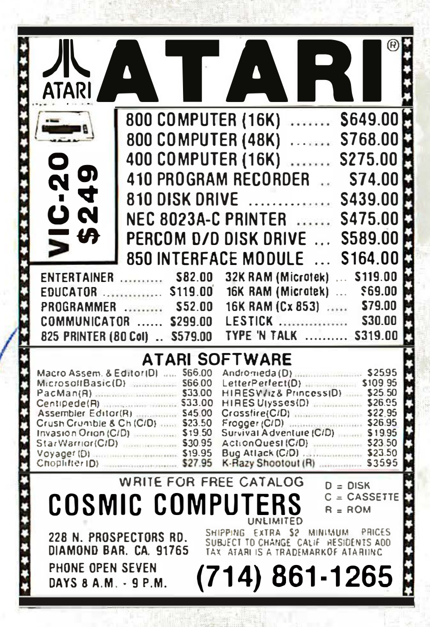
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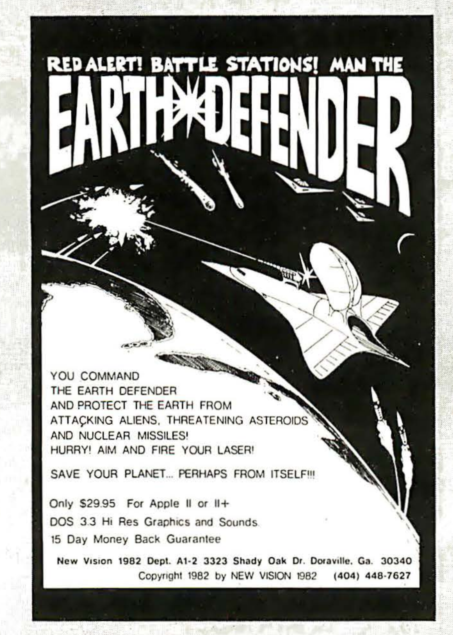
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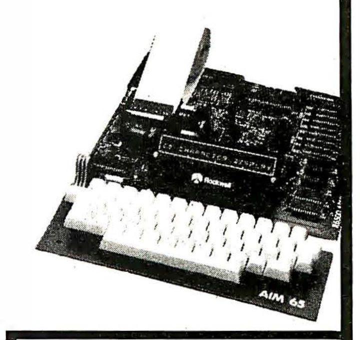
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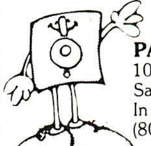
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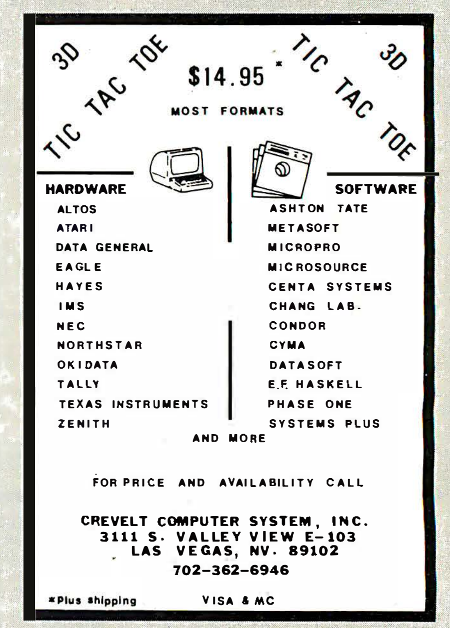


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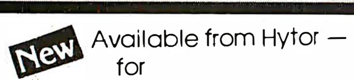
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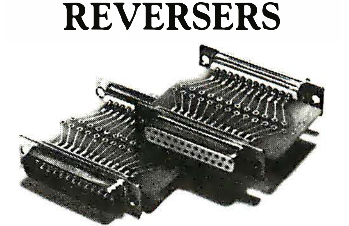
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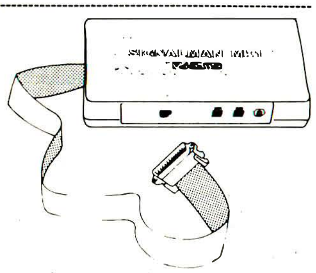
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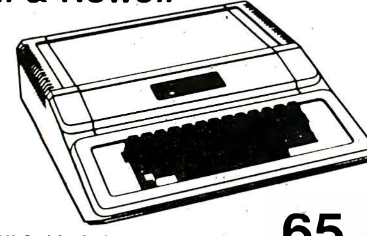
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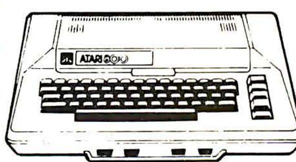
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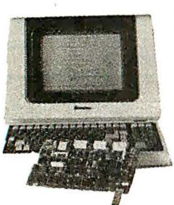
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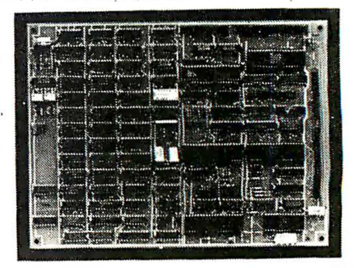
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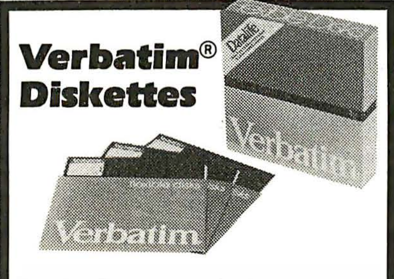
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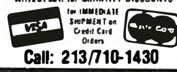


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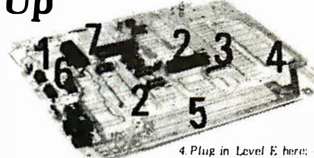
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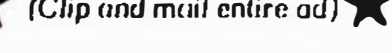
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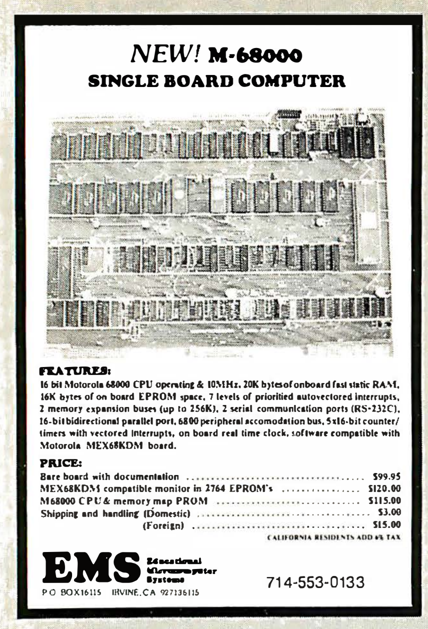
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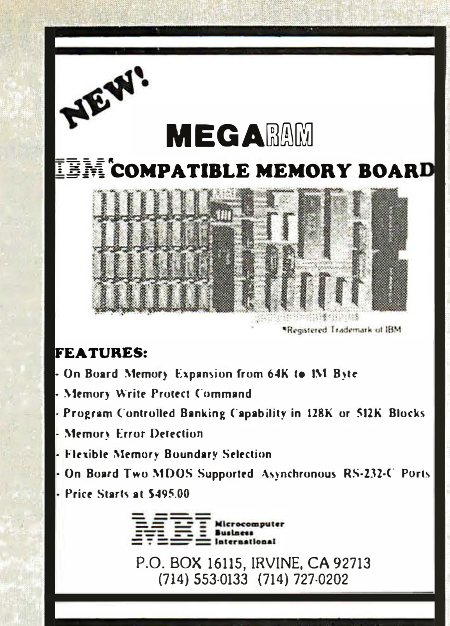
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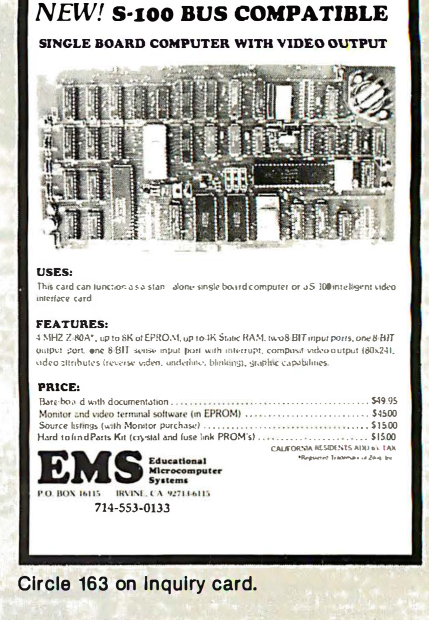
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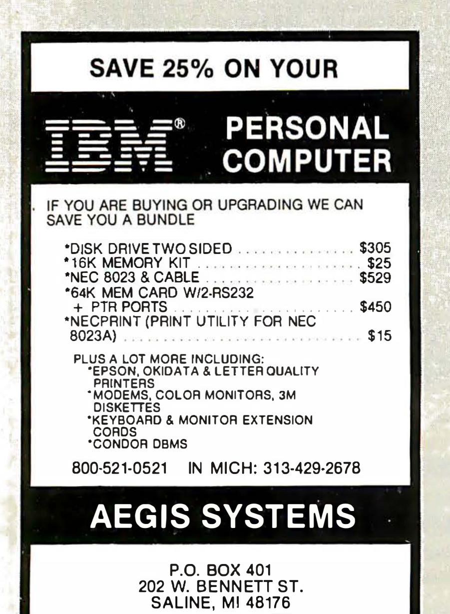
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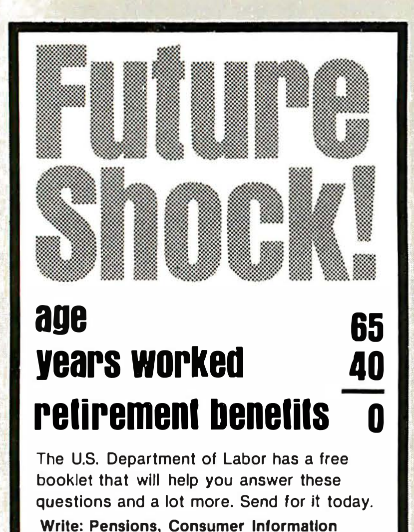
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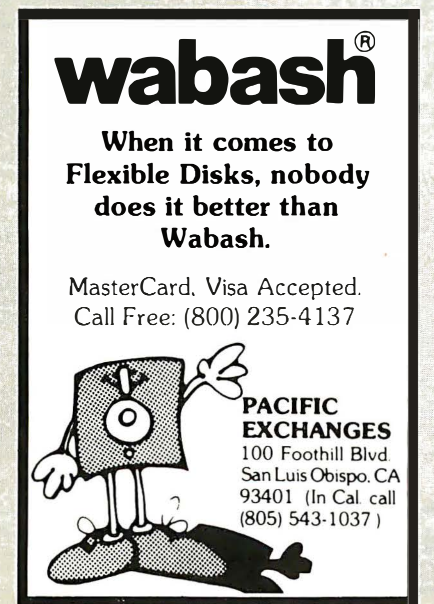
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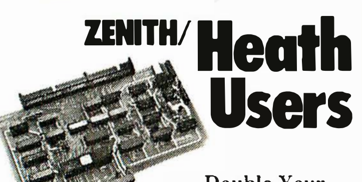
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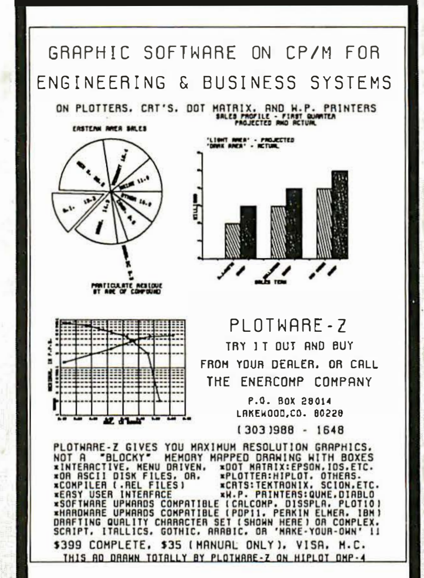
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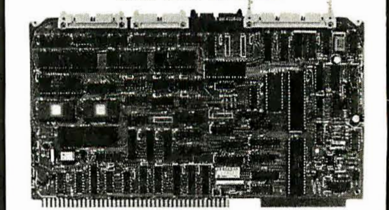
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  - A Multibus® COMPATIBLE 8086 CPU BOARD WITH DMA FLOPPY CONTROLLER, INTERRUPT CONTROLLER, PROGRAMMABLE TIMERS, 3 SERIAL PORTS, TWO PARALLEL I/O PORTS, AND 8K BYTES OF PROM WITH BOOT STRAP LOADER FOR CPM/86™.
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Printer & Disk Drive Sale

Dot Matrix Printers

NEW EPSONS with GRAFTRAX-plus

Epson has improved and upgraded their best selling line of printers to include their new GRAFTRAX-plus graphics package. Features now include; 9 x 9 matrix, bi-directional/logic seeking, line spacing to n/216, programmable forms length and horizontal tabs, skip over perf, italics fonts, international symbols, superscript/subscript, normal, emphasized, double-strike, and double-emphasized print, underlining, line drawing graphics, 60/120 DPI bit image, software reset, adjustable right margin, and true back space.

MX-80 with GRAFTRAX-plus *80/132 column, 80 CPS, adjustable pin feed, parallel interface.*

PRM-28080 *MX-80 w/GRAFTRAX-plus* **$479.95**

MX-80FT with GRAFTRAX-plus *same as MX-80 with friction feed and pin feed.*

PRM-28082 *MX-80FT w/GRAFTRAX-plus* **$559.95**

MX-100 with GRAFTRAX-plus *132/232 column, correspondence quality, up to 15" paper, friction feed & adjustable pin feed, 18 x 18 dot matrix, 80 CPS.*

PRM-28100 *MX-100 w/GRAFTRAX-plus* **$754.95**

PRA-27084	*Serial interface*	$54.95
PRA-27088	*Serial intf & 2K buffer*	$99.95
PRA-27081	*Apple card*	$39.95
PRA-27082	*Apple cable*	$19.95
PRA-27086	*IEEE 488 card*	$59.95
PRA-27087	*TRS-80 cable*	$24.95
PRA-27097	*GRAFTRAX-plus MX-80, FT*	$59.95
PRA-27197	*GRAFTRAX-plus MX-100*	$64.95
PRA-27090	*MX-80, FT print head*	$44.95
PRA-27190	*MX-100 print head*	$49.95
PRA-27083	*MX-80 ribbon cart.*	$13.95
PRA-27101	*MX-100 ribbon only*	$9.95

BETTER THAN EPSON ! - Okidata

Microline 82A *80/132 column,* ***120 CPS,*** *9 x 9 dot matrix, friction feed, pin feed, adjustable tractor feed (optional), handles 4 part forms up to 9.5" wide, rear & bottom feed, paper tear bar, 100% duty cycle/200,000,000 character print head, bi-directional/logic seeking,* ***both serial & parallel interfaces included,*** *front panel switch & program control of 10 different form lengths, uses inexpensive spool type ribbons, double width & condensed characters, true lower case descenders & graphics*

PRM-43082 *Friction & pin feed* **$499.95**

Microline 83A *132/232 column, 120 CPS, forms up to 15" wide, removable tractor, plus all the features of the 82A.*

PRM-43083 *with FREE tractor* **$744.95**

Microline 84 *132/232 column, Hi-speed 200 CPS, full dot graphics built in, plus all the features of the 83A.*

PRM-43084	*Centronics parallel*	$1149.95
PRM-43085	*Serial with 2K buffer*	$1249.95
PRA-27081	*Apple card*	$39.95
PRA-27082	*Apple cable*	$19.95
PRA-27087	*TRS-80 cable*	$24.95
PRA-43081	*2K hi speed serial card*	$99.95
PRA-43082	*Hi-res graphics ROMs 82A*	$49.95
PRA-43083	*Hi-graphics ROMs 83A*	$49.95
PRA-43088	*Tractor option for 82A*	$49.95
PRA-43080	*Extra ribbons pkg. of 2*	$9.95

8023 DOT MATRIX - NEC

100 CPS, proportional spacing, hi-resolution graphics, correspondence quality printing, bi-directional tractor & friction feed.

NEC-8023A	*8023 parallel*	$499.95
NEC-8023-01	*8023 ribbon*	$11.95

PRINTER PALS - F.M.J. Inc.

Desk top printer stand and continuous form paper holder.

PRA-99080	*for MX-80, MX-80FT, Oki 82A, NEC*	$29.95
PRA-99100	*for MX-100, Oki 83A & 84*	$34.95
PRA-99700	*for letter quality printers*	$49.95

Jade Bus Probe

THE BUS PROBE - Jade

Inexpensive S-100 Diagnostic Analyzer

Double-high S-100 board which displays all 96 IEEE S-100 signals without the expense of an ocilloscope or a front panel

TSX-200B	*Bare board*	$59.95
TSX-200K	*Kit*	$119.95
TSX-200A	*A&T*	$149.95

Dual Disk Sub-Systems

Disk Sub-Systems - Jade

Handsome metal cabinet with proportionally balanced air flow system, rugged dual drive power supply, power cable kit, power switch, line cord, fuse holder, cooling fan, never-mar rubber feet, all necessary hardware to mount 2-8" disk drives, power supply, and fan, does not include signal cable.

Dual 8" Sub-Assembly Cabinet

END-000420	*Bare cabinet*	$59.95
END-000421	*Cabinet kit*	$225.00
END-000431	*A & T*	$359.95

8" Sub-Systems - Single Sided, Double Density

END-000423	*Kit w/2 FD100-8Ds*	$975.00
END-000424	*A & T w/2 FD100-8Ds*	$1175.00
END-000433	*Kit w/2 SA-801Rs*	$999.95
END-000434	*A & T w/2 SA-801Rs*	$1195.00

8" Sub-Systems - Double Sided, Double Density

END-000426	*Kit w/2 DT-8s*	$1224.95
END-000427	*A & T w/2 DT-8s*	$1424.95
END-000436	*Kit w/2 SA-851Rs*	$1274.95
END-000437	*A & T w/2 SA-851Rs*	$1474.95

5¼" Disk Drives

Tandon TM100-1 *single-sided double-density 48 TPI*
MSM-551001 .... $248.95 ea 2 for **$219.95 ea**

Shugart SA400L *single-sided double-density 40 track*
MSM-104000 .... $234.95 ea 2 for **$224.95 ea**

Shugart SA455 *half-size double-sided 48 TPI*
MSM-104550 .... $349.95 ea 2 for **$329.95 ea**

Shugart SA465 *half-size doule-sided 96 TPI*
MSM-104650 .... $399.95 ea 2 for **$379.95 ea**

Tandon TM100-2 *double-sided double-density 48 TPI*
MSM-551002 .... $324.95 ea 2 for **$298.95 ea**

Shugart SA450 *double-sided double-density 35 track*
MSM-104500 .... $349.95 ea 2 for **$329.95 ea**

Tandon TM100-3 *single-sided double-density 96 TPI*
MSM-551003 .... $324.95 ea 2 for **$298.95 ea**

Tandon TM100-4 *double-sided double-density 96 TPI*
MSM-551004 .... $448.95 ea 2 for **$419.95 ea**

MPI B-51 *single-sided double-density 40 track*
MSM-155100 .... $234.95 ea 2 for **$224.95 ea**

MPI B-52 *double-sided double-density 40 track*
MSM-155200 .... $344.95 ea 2 for **$334.95 ea**

MPI B-91 *single-sided double-density 77 track*
MSM-155300 .... $369.95 ea 2 for **$359.95 ea**

MPI B-92 *double-sided double-density 77 track*
MSM-155400 .... $469.95 ea 2 for **$459.95 ea**

5¼" Cabinets with Power Supply

END-000216	*Single cab w/power supply*	$69.95
END-000226	*Dual cab w/power supply*	$94.95

8" Disk Drives

Shugart SA810 *half-size single-sided double-density*
MSF-108100 .... $424.95 ea 2 for **$394.95 ea**

Shugart SA860 *half-size double-sided double-density*
MSF-108600 .... $574.95 ea 2 for **$549.95 ea**

Shugart SA801R *single-sided double-density*
MSF-10801R .... $394.95 ea 2 for **$389.95 ea**

Shugart SA851R *double-sided double-density*
MSF-10851R .... $554.95 ea 2 for **$529.95 ea**

Tandon TM848-1 *single-sided double-den thin-line*
MSF-558481 .... $424.95 ea 2 for **$394.95 ea**

Tandon TM848-2 *double-sided double-den thin-line*
MSF-558482 .... $574.95 ea 2 for **$549.95 ea**

Qume DT-8 *double-sided double-density*
MSF-750080 .... $524.95 ea 2 for **$498.95 ea**

Mitsubishi M2894-63 *double-sided double-density*
MSF-289463 .... $549.95 ea 2 for **$524.95 ea**

Siemens FDD 100-8 *single-sided double-density*
MSF-201120 .... $384.95 ea 2 for **$349.95 ea**

Prices may be slightly higher at our retail locations. Please contact the store in your area for exact pricing.

Hard Disk Drives

12 MEGABYTE SUB-SYSTEM - DayStar

12 Megabyte Winchester sub-system for most CP/M based microcomputers including Apple II, S-100, IBM PC, NEC, Xerox, TRS-80 II, Heath H-89, and others. Sub-system includes interface, controller, cabinet, power supply, CP/M software patch, & cables - ready to just plug in and run. A 1 Megabyte back-up drive is also available.

MSH-531010	*S-100 sub-system*	$2095.00
MSH-531020	*Apple II sub-system*	$2095.00
MSH-531030	*NEC sub-system*	$2095.00
MSH-531040	*Xerox sub-system*	$2095.00
MSH-531050	*TRS-80 II sub-system*	$2095.00
MSH-531060	*IBM PC sub-system*	$2095.00
MSH-531099	*1 Megabyte back-up*	$699.95

12 MEGABYTE WINCHESTER - Tandon

5¼" hard disk drive for hi-speed mass storage.

MSH-550603 *Bare 5¼" drive* **$1094.95**

Letter Quality Printers

TP-1 LETTER QUALITY - SCM

10 CPS daisy wheel printer from Smith Corona.

PRD-45101	*Centronics parallel*	$699.95
PRD-45102	*Rs-232C serial*	$749.95

LETTER QUALITY PRINTER - Jade

Uses standard daisy wheels and ribbon cartridges, 16 CPS bi-directional printing, semi-automatic paper loader (single sheet or fan fold), 10/12/15 pitch, up to 16" paper, built-in noise suppression cover.

PRD-11001	*Centronics parallel*	$959.95
PRD-11002	*RS-232C serial model*	$999.95

STARWRITER F-10 - C. Itoh

New 40 CPS daisy wheel printer with full 15" carriage, uses standard Diablo print wheels and ribbons, both parallel and serial interfaces included.

PRD-22010 *Starwriter F-10* **$1495.95**

80 CPS LETTER QUALITY - Fujitsu

High speed daisy wheel printer with both RS-232C serial & Centronics parallel interfaces, emulates NEC 5510, Diablo 630, Qume, and will interface to the IBM Personal Computer, features include Z-80 CPU, 16K buffer (48K optional), bi-directional printing, & baud rates up to 19.2K

PRD-86100	*Fujitsu with 16K*	$2895.00
PRD-86200	*Fujitsu with 48K*	$3195.00
PRA-86000	*Adjustable tractor*	$190.00

Software

PLANNER CALC - Target Software

Spread sheet (what if ?) program designed with the user in mind, user oriented (simple english) commands allow you to quickly master this powerful software package, supplied on disk for most CP/M based systems.

SFA-12251052M	*Apple II 5¼" CP/M*	$49.95
SFC-12251050F	*SS SD 8" CP/M*	$49.95
SFC-12251053F	*Xerox 8" CP/M*	$49.95
SFC-12251053M	*Xerox 5¼" CP/M*	$49.95
SFX-12251051M	*NEC 5¼" CP/M*	$49.95

PAC MAN - Atari

Atari's best selling game for your 800 or 400 computer.

SFI-31254022E *Pac Man cartridge* **$37.95**

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Circle 216 on inquiry card.

Disk Drive for Apple $319.95

Diskettes

PREMIUM DISKETTES - Jade

We proudly put our name on these high quality diskettes -

5¼" Diskettes, Box of Ten

MMD-5110103	SS, SD, 01S	$29.00
MMD-5111003	SS, SD, 10S	$29.00
MMD-5111603	SS, SD, 16S	$29.00
MMD-5120103	SS, DD, 01S	$31.00
MMD-5121003	SS, DD, 010	$31.00
MMD-5121603	SS, DD, 16S	$31.00

8" Diskettes, Box of Ten

MMD-8110103	SS, SD, 01S	$31.00
MMD-8120103	SS, DD, 01S	$39.00
MMD-8220103	DS, DD, 01S	$48.00

BARGAIN DISKETTES

MMD-5110105	5¼" SS, DD, 01S	$19.95
MMD-5220105	5¼" DS, DD, 01S	$32.95
MMD-8110105	8" SS, SD, 01S	$24.95
MMD-8120105	8" SS, DD, 01S	$32.95
MMD-8220105	8" SS, DD, 01S	$35.95

Video Monitors

HI-RES 12" GREEN - Zenith

15 MHz bandwith 700 lines/inch, P31 green phosphor, switchable 40 or 80 columns, small, light-weight & portable.

VDM-201201	List price $189.95	$129.95

12" GREEN SCREEN - NEC

20 MHz bandwidth, P31 phosphor ultra-high resolution video monitor with audio.

VDM-561200	List price $289.95	$199.95

12" COLOR MONITOR - NEC

High resolution color monitor with audio.

VDC-651212	Color monitor	$389.95
NEC-1202D	RGB color monitor	$999.95

13" COLOR MONITORS - BMC

18 MHz RGB & composite video color monitors.

VDC-421320	13" RGB Color	$329.95
VDC-421310	13" Composite video	$299.95
VDX-420090	RGB card for Apple	$149.95

COLOR MONITORS - Amdek

Reasonably priced color video monitors.

VDC-80130	13" Color I	$379.95
VDC-801320	13" Color II	$894.95
IOV-2300A	DVM board for Apple	$199.95

AMBER or GREEN MONITORS - Jade

High resolution 18 MHz compact video monitors.

VDM-751210	12" Amber phosphor	$149.95
VDM-751220	12" Green phosphor	$139.95
VDM-750910	9" Amber phosphor	$149.95
VDM-750920	9" Green phosphor	$139.95

Modems

SIGNALMAN - Anchor

Direct-connect automatic answer/originate selection, 300 Baud full duplex, Bell 103, includes RS-232 cable

IOM-5600A	Signalman	$98.50

SMARTMODEM - Hayes

Sophisticated direct-connect auto-answer/auto-dial modem, touch-tone or pulse dialing, RS-232C interface, programmable

IOM-5400A	Smartmodem	$248.95
IOK-1500A	Hayes Chronograph	$218.95
IOM-2010A	Micromodem II	$328.95
IOM-1100A	Micromodem 100	$368.95

EPROM Erasers

ULTRA-VIOLET EPROM ERASERS

Inexpensive erasers for industry or home.

XME-3100A	Spectronics w/o timer	$69.50
XME-3101A	Spectronics with timer	$94.50
XME-3200A	Economy model	$39.95

Single User System

THREE BOARD SET - SD Systems

4 MHz Z-80A CPU, 64K RAM (optional 256K), serial I/O port, parallel I/O port, double density disk controller, CP/M 2.2 & manual set, system monitor, control & diagnostic software. Includes SBC-200, 64K ExpandoRAM II, Versafloppy II, & CP/M 2.2 - all boards are assembled & tested.

Board set with 64K of RAM	$1095.00
Board set with 256K of RAM	$1295.00

Apple II Accessories

16K RAM CARD - for Apple II

Expand your Apple to 64K, 1 year warranty

MEX-16700A	Save $125.00 !!!	$69.95

ADD-ON DISK DRIVE - for Apple II

Inexpensive direct replacement for Apple Disk II, works with Apple II controller as first or second drive.

MSM-123200	Add On Drive	$319.95
MSM-123100	Controller	$94.95

Z-80 CPU CARD - for Apple II

Two computers in one, Z-80 & 6502, more than doubles the power and potential of your Apple, includes Z-80 CPU card CP/M and complete manual set.

CPX-62800A	A & T with software	$249.95

8" DISK CONTROLLER - Vista

New from Vista Computer, single or double sided, single or double density, compatible with DOS 3.2/3.3, Pascal, & CP/M 2.2, Shugart & Qume compatible

IOD-2700A	A & T	$499.95

2 MEGABYTES for Apple II

Complete package includes: Two 8" double-density disk drives, Vista double-density 8" disk controller, cabinet, power supply, & cables, DOS 3.2/3.3, CP/M 2.2, & Pascal compatible.

1 MegaByte Package	Kit	$1495.00
1 MegaByte Package	A & T	$1695.00
2 MegaByte Package	Kit	$1795.00
2 MegaByte Package	A & T	$1995.95

APPLE-CAT - Novation

Software selectable 1200 or 300 baud, direct connect, auto-answer/auto-dial, auxiliary 3-wire RS232C serial port for printer.

IOM-5232A	Save $50.00!!!	$325.95

VISION 80 - Vista Computer

80 column x 24 line video card for Apple II, 128 ASCII characters, upper and lower case, 9 x 10 dot matrix with 3 dot descenders, standard data media terminal control codes, CP/M Pascal & Fortran compatible, 50/60 Hz

IOV-2400A	Vista Vision 80	$299.95

CPS MULTICARD - Mtn. Computer

Three cards in one! Real time clock/calendar, serial interface, & parallel interface - all on one card.

IOX-2300A	A & T	$179.95

HI-RES GRAPHICS CARD - Genie

Intelligent printer interface and control card allows full high resolution graphics and screen dumps.

IOP-2405A	Genie for Epson	$119.95
IOP-2410A	Genie for Okidata	$119.95
IOP-2415A	Genie for NEC/C. Itoh	$119.95

Power Strips

ISOBAR - GSC

Isolates & protects your valuable equipment from high voltage spikes & AC line noise, inductive isolated ground, 15 amp circuit breaker, U.L. listed

EME-115103	3 socket	$39.50
EME-115105	4 socket	$49.50
EME-115100	8 socket	$54.50
EME-115110	9 socket rackmount	$74.50

Single Board Computer

SUPERQUAD - Adv. Micro Digital

Single board, standard size S-100 computer system, 4 MHz Z-80A, single or double density disk controller for 5¼" or 8" drives, 64K RAM, extended addressing, up to 4K of EPROM, 2 serial & 2 parallel I/O ports, real time interrupt clock, CP/M compatible.

CPC-30800A	A & T	$724.95
IOX-4232A	Serial I/O adapter	$29.95

Z-80 STARTER KIT - SD Systems

Complete Z-80 microcomputer with RAM, ROM, I/O, keyboard, display, kludge area, manual, & workbook.

CPS-30100K	Kit with workbook	$299.95
CPS-30100A	A & T with workbook	$469.95

AIM-65 - Rockwell International

Complete 6502 microcomputer with alphanumeric display, printer, keyboard, & instruction manual.

CPK-50165A	1K AIM-65	$424.95
CPK-50465A	4K AIM-65	$474.95
SFK-74600008E	8K Basic ROM	$64.95
SFK-64600004E	4K assembler ROM	$43.95
SFK-74600020E	PL/65 ROM	$84.95
SFK-74600010E	Forth ROM	$64.95
SFK-74600030E	Instant Pascal	$99.95
PSX-030A	Power supply	$64.95
ENX-000002	Enclosure	$54.95

SPECIAL PACKAGE

4K AIM-65, 8K Basic, power supply, & enclosure

Special Package Price	$649.95

S-100 EPROM Boards

PROM-100 - SD Systems

2708, 2716, 2732 EPROM programmer with software.

MEM-99520K	Kit with software	$189.95
MEM-99520A	A & T with software	$249.95

PB-1 - SSM Microcomputer

2708, 2716 EPROM board with on-board programmer.

MEM-99510K	Kit with manual	$154.95
MEM-99510A	A & T with manual	$219.95

EPROM BOARD - Jade

16K or 32K uses 2708 or 2716 EPROMs, 1K boundary.

MEM-16230K	Kit w/o EPROMs	$79.95
MEM-16230A	A & T w/o EPROMs	$119.95

S-100 Video Boards

SPECTRUM COLOR - CompuPro

Full-function color graphics board, up to 8 colors, 256 x 192 graphics, parallel I/O port, 8K RAM.

IOV-1870A	A & T	$348.95
IOV-1870C	CSC	$398.95

MICROANGELO - Scion

Ultra-high-resolution 512 x 480, 256 color or black & white S-100 video board

IOV-1500A	A & T	$999.95

S-100 MotherBoards

ISO-BUS - Jade

Silent, simple, and on sale - a better motherboard

6 Slot (5¼" x 8⅝")

MBS-061B	Bare board	$19.95
MBS-061K	Kit	$39.95
MBS-061A	A & T	$59.95

12 Slot (9¾" x 8⅝")

MBS-121B	Bare board	$29.95
MBS-121K	Kit	$69.95
MBS-121A	A & T	$99.95

18 Slot (14½" x 8⅝")

MBS-181B	Bare board	$49.95
MBS-181K	Kit	$99.95
MBS-181A	A & T	$139.95

ACTIVE TERMINATOR - CompuPro

A true mother's helper.

TSX-100A	A & T	$59.45

Prices may be slightly higher at our retail locations. Please call the store nearest you for local price and availability.

Circle 217 on inquiry card.

CompuPro Boards on Sale

S-100 CPU Boards

8086/8087 - CompuPro
16 bit, 8 or 10 MHz 8086 CPU with provisions for 8087 & 80130.

CPU-70520A	8 MHz 8086 A & T	$624.95
CPU-70520C	8 MHz 8086 CSC	$764.95
CPU-70530A	with 8087 A & T	$1224.95
CPU-70530C	with 8087 CSC	$1455.95

8085/8086 - CompuPro
Both 8 & 16 bit CPUs, standard 8 bit S-100 bus, up to 8 MHz, accesses 16 Megabytes of memory.

CPU-20510A	6 MHz A & T	$398.95
CPU-20510C	6/8 MHz CSC	$497.95

CPU-Z - CompuPro
2/4 MHz Z80A CPU, 24 bit addressing.

CPU-30500A	2/4 MHz A & T	$279.95
CPU-30500C	3/6 MHz CSC	$374.95

SBC-200 - SD Systems
4 MHz Z-80A CPU with serial & parallel I/O, 1K RAM, 8K ROM space, monitor PROM included.

CPC-30200A	A & T	$399.95

THE BIG Z - Jade
2 or 4 MHz switchable Z-80 CPU board with serial I/O, accomodates 2708, 2716, or 2732 EPROM, baud rates from 75 to 9600.

CPU-30201B	Bare board w/manual	$35.00
CPU-30201K	Kit with manual	$149.95
CPU-30210A	A & T with manual	$199.95

CB-2 - SSM Microcomputer
2 or 4 MHz Z-80 CPU board with provision for up to 8K of ROM or 4K of RAM on board, extended addressing, IEEE S-100, front panel compatible.

CPU-30300K	Kit with manual	$229.95
CPU-30300A	A & T with manual	$274.95

2810 Z-80 CPU - C.C.S.
2 or 4 MHZ Z-80 CPU with serial I/O port & on-board monitor PROM, front panel compatible.

CPU-30400A	A & T with PROM	$289.95

2820 Z-80 DMA CPU - C.C.S.
4 MHz Z-80 CPU board with 2 serial I/O ports & Centronics parallel I/O port, separate data & status ports, DMA daisy chain compatible.

CPU-30420A	A & T with manual	$569.95

S-100 Disk Controllers

DISK 1 - CompuPro
8" or 5¼" DMA disk controller, single or double density, single or double sided, 10 MHz.

IOD-1810A	A & T	$449.95
IOD-1810C	CSC	$554.95
SFC-52506580F	8" CP/M 2.2 for Z-80	$174.95
SFC-52506586F	8" CP/M 2.2 for 8086	$299.95
SFO-54158000F	Oasis single user	$499.95
SFO-54158002F	Oasis multi-user	$849.95

VERSAFLOPPY II - SD Systems
Double density disk controller for any combination of 5¼" and 8" single or double sided, analog phase-locked loop data separator, vectored interrupts, CP/M 2.2 & Oasis compatible, control/diagnostic software PROM included.

IOD-1160A	A & T with PROM	$359.95
SFC-55009047F	CP/M 2.2 with VF II	$99.95

2242 DISK CONTROLLER - C.C.S.
5¼" or 8" double density disk controller with on-board boot loader ROM, free CP/M 2.2 & manual set.

IOD-1300A	A & T with CP/M 2.2	$399.95

DOUBLE D - Jade
High reliablity double density disk controller with on-board Z-80A, auxiliary printer port, IEEE S-100, can function in multi-user interrupt driven bus.

IOD-1200B	Bare board & hdwr man	$59.95
IOD-1200K	Kit w/hdwr & sftwr man	$299.95
IOD-1200A	A & T w/hdwr & sftwr man	$359.95
SFC-59002001F	CP/M 2.2 with Double D	$99.95

S-100 Memory Boards

256K RAMDISK - SD Systems
ExpandoRAM III expandable from 64K to 256K using 64K x 1 RAM chips, compatible with CP/M, MP/M, Oasis, Cromemco, & most other Z-80 based systems, functions as ultra-high speed disk drive when used with optional RAMDISK software.

MEM-65064A	64K A & T	$474.95
MEM-65128A	128K A & T	$574.95
MEM-65192A	192K A & T	$674.95
MEM-65256A	256K A & T	$774.95
SFC-55009000F	RAMDISK sftwr CP/M 2.2	$44.95
SFC-55009000F	RAMDISK with EXRAM III	$24.95

128K RAM 21 - CompuPro
128K x 8 bit or 64K x 16 bit static RAM board, 12 MHz, 24 bit addressing.

MEM-12810A	A & T	$1609.95
MEM-12810C	CSC	$1794.95

64K RAM 17 - CompuPro
64K CMOS static RAM board, 10 MHz, low power less than 4 watts, DMA compatible, 24 bit addressing.

MEM-64180A	64K A & T	$549.95
MEM-64180C	64K CSC	$698.95

64K RAM 16 - CompuPro
32K x 16 bit or 64K x 8 bit low power static RAM board, 10 MHz, 24 bit addressing.

MEM-32180A	RAM 16 A & T	$598.95
MEM-32180C	RAM 16 CSC	$698.95

64K STATIC RAM - SSM
IEEE 696/S-100 standard, up to 6MHz/8 Bit, 12MHz/16 Bit, 24 Bit extended addressing, disable-able in 2K increments

MEM-64300A	A & T	$499.95

64K STATIC RAM - Mem Merchant
64K static S-100 RAM card, 4 to 16K banks up to 8 MHz.

MEM-64400A	64K A & T	$499.95

2065 64K RAM - C.C.S.
4 MHz bank port/bank byte selectable, extended addressing, 16K bank selectable, front panel compatible.

MEM-64565A	64K A & T	$349.95

2066 64K RAM - C.C.S.
64K RAM board with bank and block select switching functions for Cromemeco Cromix & Alpha Micro.

MEM-64566A	64K A & T	$424.95

64K EXPANDORAM II - SD Systems
Expandable RAM board from 16K to 64K using 4116 RAM chips.

MEM-16630A	16K A & T	$344.95
MEM-32631A	32K A & T	$364.95
MEM-48632A	48K A & T	$384.95
MEM-64633A	64K A & T	$399.95

MEMORY BANK - Jade
4 MHz S-100 bank selectable expandable to 64K.

MEM-99730B	Bare board w/manual	$49.95
MEM-99730K	Kit with no RAM	$179.95
MEM-32731K	32K kit	$199.95
MEM-64733K	64K kit	$249.95
Assembled & Tested		add $50.00

32K RAM 20 - CompuPro
32K static RAM, up to 10 MHz, disable-able in 4K banks, bank select or 24 bit addressing.

MEM-16180A	16K A & T	$259.95
MEM-16180C	16K CSC	$324.95
MEM-24180A	24K A & T	$324.95
MEM-24180C	24K CSC	$384.95
MEM-32185A	32K A & T	$384.95
MEM-32185C	32K CSC	$449.95

16K STATIC RAM - Mem Merchant
4MHz lo-power static RAM board, IEEE S-100, bank selectable, addressable in 4K blocks, disable-able in 1K segments extended addressing.

MEM-16171A	16K A & T	$149.95

S-100 I/O Boards

SYSTEM SUPPORT 1 - CompuPro
Real time clock, three 16 bit interval timers, dual interrupt controllers (15 levels), up to 4K EPROM/RAM, RS-232C serial channel, provision for 9511A/9512 math chip.

IOX-1850A	SS1 A & T	$359.95
IOX-1850C	SS1 CSC	$459.95
IOX-1855A	with 9511 A & T	$554.95
IOX-1855C	with 9511 CSC	$654.95
IOX-1860A	with 9512 A & T	$554.95
IOX-1860C	with 9512 CSC	$654.95

INTERFACER 1 - CompuPro
2 serial I/O ports 50-19.2K baud.

IOI-1810A	A & T	$218.95
IOI-1810C	CSC	$288.95

INTERFACER 2 - CompuPro
3 parallel, 1 serial, & interrupt timer.

IOI-1820A	A & T	$218.95
IOI-1820C	CSC	$288.95

INTERFACER 3 - CompuPro
5 or 8 channel serial I/O board for interrupt driven multi-user systems up to 250K baud.

IOI-1835A	5 port A & T	$558.95
IOI-1835C	5 port CSC	$628.95
IOI-1838A	8 port A & T	$628.95
IOI-1838C	8 port CSC	$749.95

INTERFACER 4 - CompuPro
3 serial, 1 parallel, 1 Centronics parallel.

IOI-1840A	A & T	$314.95
IOI-1840C	CSC	$414.95

MPX - CompuPro
Multi-user I/O multiplexer & interrupt controller with on-board 8085A-2 CPU & 4K or 16K of RAM.

IOI-1875A	4K MPX A & T	$444.95
IOI-1875C	4K MPX CSC	$534.95
IOI-1880A	16K MPX A & T	$584.95
IOI-1880C	16K MPX CSC	$674.95

I/O-8 - SSM Microcomputer
Eight software programmable serial I/O ports, 110 -19.2K Baud, ideal for multi-user systems

IOI-1018A	A & T	$469.95

I/O-5 - SSM Microcomputer
Two serial & 3 parallel I/O ports, 110-19.2K Baud

IOI-1015A	A & T	$289.95

MPC-4 - SD Systems
Intelligent 4-port serial I/O card, on-board Z-80A, 2K RAM, 4K PROM area, on-board firmware, fully buffered, vectored interrupts, four CTC channels, add to SD Board set for powerful multi-user system

IOI-1504A	A & T w/software	$495.00

I/O-4 - SSM Microcomputer
2 serial I/O ports plus 2 parallel I/O ports.

IOI-1010B	Bare board w/manual	$35.00
IOI-1010K	Kit with manual	$179.95
IOI-1010A	A & T with manual	$249.95

2830 6 PORT SERIAL - C.C.S.
Six asynchronous RS-232C serial I/O ports with programmable baud rates.

IOI-1040A	A & T with manual	$529.95

2710 4 PORT SERIAL - C.C.S.
Four RS-232C serial I/O ports with full handshaking.

IOI-1060A	A & T with manual	$319.95

2719 2 SER & 2 PAR - C.C.S.
Two RS-232C serial I/O ports plus two 8 bit parallel I/O ports.

IOI-1080A	A & T with manual	$349.95

Prices may be slightly higher at our retail locations. Please call the store nearest you for local price and availability.

Circle 217 on inquiry card.

UTIC Mini Stereo AM/FM Receiver

WITH HEADPHONES — For Joggers, Cyclists, Skaters & Sports Events



FEATURES: Lightweight headphones. Left/right balance control. Full fidelity stereo sound. Additional black soft carrying case & shoulder strap. Belt clip (hands free). Operates on 3 AA cell batteries (not incl.). Compact size: 3⅞" x 4⅞" x 1". Wt. 6 oz.

Model 2830 List Price $59.95 . . . . **$34.95**

SPEAKERS



2¼" Round — 8 Ohm
.25 Watt (4" Leads)
Size: 2¼" x ¾"

Part No.	Price
A0201	$1.25 or 2/1.98

2½" Square — 16 Ohm
.25 Watt (4 mount. holes)
Large Ceramic Magnet
Size: 2⅞" x 2⅞" x ¾"

Part No.	Price
SF-25016	$1.39 or 2/2.98

MOTOROLA

AM/FM Stereo Push Button CAR RADIO

FOR VOLKSWAGEN SCIROCCO, RABBIT, AUDI 5000 AND FOX

(with minor adjustments, can be used in any automobile)





Includes bezel trim and everything pictured. Two each 4x6 speakers and grille (1½" deep). All cables and leads for hook-up. Includes all instruction Manuals for easy installation. Cut-out dimensions: 7"W x 1¾"H x 6½"L.

Model 5VW3901 . . . . **$49.95**

UV-EPROM Eraser



Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

UVS-11EL Replacement Bulb $16.95

DE-4 UV-EPROM Eraser **$79.95**

JOYSTICKS

JS-5K





JVC-40

JS-5K	5K Linear Taper Pots	$5.25
JS-100K	100K Linear Taper Pots	$4.95
JS-150K	150K Linear Taper Pots	$4.75
JVC-40	40K (2) Video Controller in case	$4.95

5¼" Mini-Floppy Disc Drive

Pertec Computer Corp.

FOR TRS-80 MODEL I, III (Industry Standard)



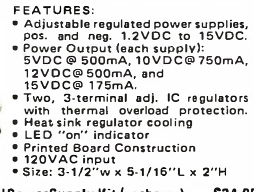
Features single or double density. Recording mode: FM single, MFM double density. Power: +12VDC (±0.6V) 1.6 amps max., 5VDC (±0.25V) 0.8 amps max. Unit as pictured at left (does not incl. case, power supply or cables). 30-page data book included. Weighs 3½ pounds. Size: 5¾"W x 8"D x 3¼"H

Limited Quantity!

Part No.	Price
FD200 — Single-sided, 40 tracks, 250K bytes capacity	$179.95
FD250 — Double-sided, 35 tracks, 438K bytes capacity	$199.95

JE215 Adjustable Dual Power Supply

General Description: The JE215 is a Dual Power Supply with independent adjustable positive and negative output voltages. A separate adjustment for each of the supplies provides the user unlimited applications for IC current voltage requirements. The supply can also be used as a general all-purpose variable power supply.

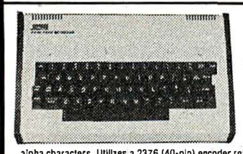


FEATURES:
- Adjustable regulated power supplies, pos. and neg. 1.2VDC to 15VDC.
- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 500mA, and 15VDC @ 175mA.
- Two, 3-terminal adj. IC regulators with thermal overload protection.
- Heat sink regulator cooling
- LED "on" indicator
- Printed Board Construction
- 120VAC input
- Size: 3-1/2"w x 5-1/16"L x 2"H

JE215 Adj. Duel Power Supply Kit (as shown) . . $24.95

(Picture not shown but similar in construction to above)
JE200 Reg. Power Supply Kit (5VDC, 1 amp) . . $14.95
JE205 Adapter Brd. (to JE200) ±5, ±9 & ±12V. $12.95
JE210 Var. Pwr. Sply. Kit, 5-15VDC, to 1.5amp. $19.95

KEYBOARDS — POWER SUPPLIES



JE610 ASCII Encoded Keyboard Kit

The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with industrial grade keyboard switch assembly (62-keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and −12V @ 10mA for operation. Features: 60 keys generate the 126 characters, upper and lower case ASCII set. Fully buffered. Two user-define keys provided for custom applications. Capslock for upper-case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector. Size: 3½"H x 14½"W x 8¾"D.

JE610/DTE-AK (After assembly as pictured above) **$124.95**

JE610 Kit 62-Key Keyboard, PC Board & Components (no case) . . . . . . **$ 79.95**
K62 62-Key Keyboard (Keyboard only) . . . . **$ 34.95**
DTE-AK (case only — 3¼"H x 11"W x 8¾"D) . . . . **$ 49.95**

JE212 — Negative 12VDC Adapter Board Kit for JE610 ASCII KEYBOARD KIT
Provides —12VDC from incoming 5VDC $9.95

JE600 Hexadecimal Encoder Kit

FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD

The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Debounce circuit provided for all 19 keys. Nine LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation. Size: 3½"H x 8¼"W x 8¾"D.

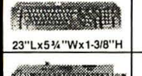
JE600/DTE-HK (After assembly as pictured above) **$99.95**

JE600 Kit 19-Key Hexadecimal Keyboard, PC Board & Components (no case) **$59.95**
K19 19-Key Keyboard (Keyboard only) **$14.95**
DTE-HK (case only — 3½"H x 8¼"W x 8¾"D) **$44.95**

ALPS 26-KEY CALCULATOR KEYBOARD (9½"Lx4¼"Wx1"H)
Gray Key Caps with blue, green and white back drop. Mechanical SPST Switching: 22-pin Edge Card Connection.
Part No. KB26 . . . . $2.95 each or 2/$4.95

MICRO SWITCH 69-KEY KEYBOARD (16⅞"L x 5¼"W x 1⅞"H)
Data Entry Keyboard, Encoded Output: 8-bit Parallel EBC DIC. Switching: Hall Effect, 24-pin Edge Card Connection. Complete with Pin Connection.
Part No. KB69SD12-2 . . . . $19.95 each

DATANETICS 74-KEY KEYBOARD (16¾"L x 5½"W x 1⅞"H)
ASCII Encoded Keyboard, Output: Even Parity ASCII, Supply voltage +5, -12 volt. Switching: Mechanical SPST — 50-pin Connection. Complete with Pin Connection.
Part No. KB354 . . . . $29.95 each



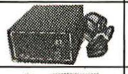
MICRO SWITCH 85-KEY KEYBOARD (23"Lx5¾"Wx1-3/8"H)
DataEntry Keyboard. Switching: Hall Effect, 13-pin Edge Card Connection. Metalframe, dark brown keycaps.
Part No. 85SD18-1 . . . . $29.95 each

MICRO SWITCH 88-KEY KEYBOARD (18¼"L x 5¾"W x 1⁵⁄₁₆"H)
Data Entry Keyboard used in a Diablo 1640 Terminal. Supply Voltage: +5V, -12V. Switching: Hall Effect — 10-pin Edge Card Connection. Schematic Included.
Part No. 88SD22 . . . . $69.95 each

POWER SUPPLIES



POWER SUPPLY — 5VDC @ 1 AMP REGULATED — TransactionTech
Output +5VDC @ 1 amp (also +30VDC) reg. Input 115VAC 60Hz. Two-tone (black/beige) self-enclosed case, 6 ft., 3 cond. black power cord. Size: 6½"W x 7"D x 2¼"H. Wt. 3 lbs.
Part No. PS51194 . . . . $19.95 each



POWER SUPPLY — 5VDC @ 1 AMP REGULATED — B Industries
Output +5VDC @ 1 amp, +36-42VDC adj. 400mA or less, 30VAC (isol.) @ 1.5 amp. Input 115VAC 60Hz. Circ. brkr. re-set button. Blk. self-encl. case w/4 rubber feet. 6 ft., 3 cond. blk. pow. cord. On/off switch. 6¾"W x 7¾"D x 3-7/8"H - wt. 7 lbs.
Part No. PS407D . . . . $24.95 each



POWER SUPPLY — 5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp. Fan volt./power supply select switches (115/230VAC). Output: 5VDC @ 7.6 amp, 12VDC @ 1.6 amp. 8 ft. blk. pow. cord. 11½"W x 13¼"D x 3¾"H. Wt. 6 lbs.
Part No. PS94VO . . . . $49.95 each

POWER PAC — Heavy Duty Multi-Voltage Power Supply — 5VDC, 12VDC, 24VDC
Output: +5VDC @ 30A, +12VDC @ 2A, -12VDC @ 4A & +24VDC @ 3A. Input: 115VAC, 7A, 220VAC, 3.5A. Reg.: ± .15% line & load comb. Ripple: 10MV peak to peak (3MV RMS). Overvolt. protect.: 5V, +12V, -12V. Overcur. protect. Incl. 15½"L x 6"H x 11-7/8"D. Wt. 40 lbs.
Part No. 285-016 . . . . $89.95 each

★ SHIPMENT IN 24 HOURS ★
6:00 AM to 6:00 PM (PST)
Call: (415) 592-8097

JUMPER AND CABLE ASSEMBLIES

Custom Jumpers! *Custom Cables!*

STANDARD DIP JUMPERS

All jumpers use low profile dip plugs with heavy duty pins for repeated disconnect applications.

JAMECO Part No.	AP Cross-Reference	No. Pins	Description	Wire Length	Price
DJ14-1	924102-12	14	single end	12"	$1.79
DJ14-2	924102-24	14	single end	24"	2.05
DJ14-3	924102-36	14	single end	36"	2.35
DJ14-1-14	924106-12	14	double end	12"	3.20
DJ14-2-14	924106-24	14	double end	24"	3.49
DJ14-3-14	924106-36	14	double end	36"	3.79
DJ16-1	924112-12	16	single end	12"	1.85
DJ16-2	924112-24	16	single end	24"	2.19
DJ16-3	924112-36	16	single end	36"	2.59
DJ16-1-16	924116-12	16	double end	12"	3.35
DJ16-2-16	924116-24	16	double end	24"	3.69
DJ16-3-16	924116-36	16	double end	36"	4.05
DJ24-1	924122-12	24	single end	12"	2.69
DJ24-2	924122-24	24	single end	24"	3.39
DJ24-3	924122-36	24	single end	36"	3.95
DJ24-1-24	924126-12	24	double end	12"	4.79
DJ24-2-24	924126-24	24	double end	24"	5.29
DJ24-3-24	924126-36	24	double end	36"	5.89

JAMECO Part No.	AP Cross-Reference	No. Pins	Description	Wire Length	Price
DJ40-1	924132-12	40	single end	12"	5.89
DJ40-2	924132-24	40	single end	24"	6.79
DJ40-3	924132-36	40	single end	36"	7.69
DJ40-1-40	924136-12	40	double end	12"	10.95
DJ40-2-40	924136-24	40	double end	24"	11.89
DJ40-3-40	924136-36	40	double end	36"	12.79

STANDARD DB25 SERIES CABLES

Now you can order DB25 P or S connectors with the cable necessary to fit your application. Choose from our standard flat cable in 4-foot lengths. **Call today.**

STANDARD CABLES

Part No.	Cable Length	Connectors	Price
DB25P-4	4 feet	1-DB25P	$ 9.95 ea.
DB25S-4	4 feet	1-DB25S	10.95 ea.
DB25P-4-P	4 feet	2-DB25P	16.95 ea.
DB25P-4-S	4 feet	1-DB25P/1-DB25S	17.95 ea.
DB25S-4-S	4 feet	2-DB25S	18.95 ea.

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6% Sales Tax
Postage — Add 5% plus $1.50 Insurance
Send S.A.S.E. for Monthly Sale Flyer!

Spec Sheets — 25¢ each
Send 88¢ Postage for your *FREE* 1982 JAMECO CATALOG
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8/82

BOOKS

National Semiconductor — Intersil — Intel

30001	National CMOS Data Book (640 pages) 74C, CD4000, and A/D Converters	$5.95
30002	National Interface Data Book (704 pages) DP, DS8000, DS3600, DS75000, etc.	$5.95
30003	National Linear Data Book (1376 pages) LM, LF, ADC, DAC, LH Series	$11.95
30004	National Series80 — Board Leval Computer (224 pages)	$4.95
30005	National TTL Logic Data Book (624 pages) 7400, LS, L, H, S, and DM8000 Series	$8.95

30006 Above (3) 30001,3,5 as set $24.95/lot

010400	Intel Component Data Catalog — Full data sheets for Intel's products incl. memory devices, microproc., peripherals & indust./mil. products (1328 pages)	$14.95
205610	Intel Peripheral Design Handbook — Full data sheets, appl. notes for Intel peripheral device components (644 pages)	$9.95

AC and DC Wall Transformers



Part No. DC6912

With Universal Plug and 9V Battery Snap

Selective voltages: 6,9,12VDC. Polarity selection (+/-). six-foot line from adapter to plugs — six-inch line from adapter to battery snap. *120V/60Hz. 300mA.*

Part No.	Input	Output	Price
AC 250	117V/60Hz	12VAC 250mA	$3.95
AC 500	117V/60Hz	12VAC 500mA	$4.95
AC1000	117V/60Hz	12VAC 1 amp	$5.95
AC9004	117V/60Hz	9.2VAC 2.5amp	$2.95 or 2/$4.95
DC 800	120V/60Hz	8VDC400mA	$1.95 or 2/$2.95
DC6912 (above)	120V/60Hz	6,9,12VDC 300mA	$9.95
DV5490	117V/60Hz	9.5VDC 275mA	$2.49 or 2/$3.95
DC900	120V/60Hz	9VDC 500mA	$3.95
DC1200	120V/60Hz	12VDC 300mA	$2.95 or 2/$4.95

CONNECTORS



Computer Users!

DB25P	D-Subminiature Plug	$2.95
DB25S	D-Subminiature Socket	$3.50
D20418-2	Screw L ck Hdwr.(2) DB25S/P	2/$.99
DB51226	Cover for DB25P/S	$1.75
22/44SE	P.C. Edge (22/44 Pin)	$2.95
UG88/U	BNC Plug	$1.79
UG89/U	BNC Jack	$3.79
UG175/U	UHF Adapter	$ .49
SO239	UHF Panel Recp.	$1.29
PL258	UHF Adapter	$1.60
PL259	UHF Plug	$1.60
UG260/U	BNC Plug	$1.79
UG1094/U	BNC Bulkhead Recp.	$1.29

TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K or 32K

Kit comes complete with:
- 8 ea. MM5290 (UPD416/4116) 16K Dyn. Ram (*ns)
- Documentation for conversion

TRS-16K2	*150ns	$19.95
TRS-16K3	*200ns	$16.95
TRS-16K4	*250ns	$14.95

Mostek DC/DC Converter



+5 VOLTS TO -9 VOLTS

Input: +5V. Output: -9V (regulated) @ 30mA. Printed circuit mounting.

DC10 . . . . $2.95 ea. or 2/$4.95

Sorensen Regulated Power Supplies

Sorensen's open construction (SOC) power supplies are series-regulated solid-state systems, designed to provide regulated DC voltages at six levels (2-28 volt range). Units are open-framed on sturdy black anodized aluminum for excellent mounting.

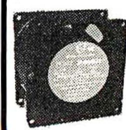
FEATURES: 115/208/230 VAC Input @ 50-63Hz. Low Ripple: 1.5mVrms, 5mV P-P max. Adjustable current limit. Voltage adjustment control. Temperature-compensated circuitry. Optional over-voltage protection. All schematics and specifications supplied with unit. Series A, B, C, E have 3 mounting surfaces (Series F, bottom mounting only).



SPECIFICATION CHART

Part No.	Series	Output Volt. Adjust. Range		Output Current (Adc)			Size (Inches)	Wt. lbs.	Price
		min.	max.	40°C	50°C	60°C			
SOC 2-6	B	1.9	2.1	6.0	4.9	3.8	5.62x4.88x2.50	4.3	19.95
SOC2-25	F	1.9	2.1	25.0	21.5	17.5	16.00x4.88x4.88	16.0	29.95
SOC5-3	A	4.75	5.25	3.0	2.4	1.8	4.00x4.88x1.62	2.0	24.95
SOC5-18	E	4.25	5.25	18.0	15.0	12.0	14.00x4.88x2.75	12.0	39.95
SOC5-25	F	4.25	5.25	25.0	21.5	17.5	16.00x4.88x4.88	16.0	49.95
SOC12-11	E	11.4	12.6	11.0	9.2	6.8	14.00x4.88x1.62	12.0	44.95
SOC12-15	F	11.4	12.6	15.0	12.75	9.5	16.00x4.88x4.88	16.0	49.95
SOC15-5	C	14.25	15.75	5.0	4.2	3.5	7.00x4.88x3.37	6.6	39.95
SOC15-9.5	E	14.25	15.75	9.5	7.6	5.6	14.00x4.88x1.62	12.0	44.95
SOC15-13	F	14.25	15.75	13.0	10.5	8.0	16.00x4.88x4.88	16.0	49.95
SOC28-0.8	A	26.6	29.4	0.8	.64	.45	4.00x4.88x1.62	2.0	24.95

Pee Wee Boxer Fan



- 36cfm free air delivery
- 3.125" sq. x 1.665" depth
- 10 yrs. cont. duty at 20°C
- 115V 50/60Hz
- For Apple users

PWS2107U Cleaned & tested (used) . . . . $ 9.95 ea.
PWS2107F New . . . . $14.95 ea.

Muffin® Fan



- 105cfm free air delivery
- 4.68" sq. x 1.50" depth.
- 10 yrs. cont. duty at 20°C
- Impedance protected, ambients to 70°C
- 115V 50/60Hz 14W Wt. 17 oz.

MU2A1-U Cleaned & tested (used) . . . . $9.95 ea.
MU2A1-N New . . . . $14.95 ea.

1/2 PRICE SALE! — COMPUTER GRADE CAPACITORS

mfd	wvdc	price	mfd	wvdc	price	mfd	wvdc	price	mfd	wvdc	price
250	150	1.95	4,500	50	3.95	20,000	20	2.95	43,000	10	5.95
500	200	2.49	5,500	25	4.49	21,000	15	3.95	45,000	5	5.95
1,250	3	.99	6,100	40	2.49	22,000	15	4.95	52,000	20	5.95
1,500	25	1.95	7,000	60	4.95	23,000	7	1.95	55,000	15	5.95
1,500	50	2.95	10,000	15	2.95	23,000	10	2.95	58,000	20	5.95
2,000	10	2.95	10,000	16	3.95	23,000	20	3.95	65,000	10	7.95
2,100	200	2.95	11,000	19	4.95	24,000	20	2.95	73,800	5	7.95
2,250	100	3.95	13,000	16	2.95	27,000	10	2.95	80,000	15	9.95
2,300	33	2.95	14,000	13	2.95	32,500	25	4.95	90,000	10	8.95
2,500	15	2.95	14,000	35	3.95	40,000	25	5.95	120,000	15	10.95
3,000	25	1.95	18,000	10	3.95	42,000	10	4.95	160,000	10	8.95
3,600	40	3.95									

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7400

SN7400N	.20	SN7472N	.29	SN74156N	.79
SN7401N	.20	SN7473N	.35	SN74157N	.69
SN7402N	.25	SN7474N	.35	SN74160N	.89
SN7403N	.25	SN7475N	.49	SN74161N	.89
SN7404N	.25	SN7476N	.35	SN74162N	.89
SN7405N	.29	SN7479N	5.00	SN74163N	.89
SN7406N	.35	SN7480N	.50	SN74164N	.89
SN7407N	.35	SN7482N	.99	SN74165N	.89
SN7408N	.29	SN7483N	.69	SN74166N	1.25
SN7409N	.29	SN7485N	.89	SN74167N	2.79
SN7410N	.25	SN7486N	.35	SN74170N	1.95
SN7411N	.29	SN7489N	1.75	SN74172N	4.95
SN7412N	.35	SN7490N	.49	SN74173N	1.39
SN7413N	.40	SN7491N	.59	SN74174N	.99
SN7414N	.69	SN7492N	.45	SN74175N	.89
SN7416N	.29	SN7493N	.45	SN74176N	.79
SN7417N	.29	SN7494N	.69	SN74177N	.79
SN7420N	.25	SN7495N	.69	SN74179N	1.49
SN7421N	.29	SN7496N	.69	SN74180N	.79
SN7422N	.45	SN7497N	3.00	SN74181N	2.25
SN7423N	.29	SN74100N	1.49	SN74182N	.79
SN7425N	.29	SN74104N	.89	SN74184N	2.49
SN7426N	.29	SN74105N	.89	SN74185N	2.49
SN7427N	.25	SN74107N	.35	SN74190N	1.25
SN7428N	.49	SN74109N	.39	SN74191N	1.25
SN7430N	.25	SN74116N	1.95	SN74192N	.89
SN7432N	.29	SN74121N	.39	SN74193N	.89
SN7437N	.25	SN74122N	.55	SN74194N	.89
SN7438N	.40	SN74123N	.59	SN74195N	.69
SN7439N	.25	SN74125N	.49	SN74196N	.89
SN7440N	.20	SN74126N	.49	SN74197N	.89
SN7441N	.89	SN74132N	.75	SN74198N	1.49
SN7442N	.59	SN74136N	.75	SN74199N	1.49
SN7443N	1.10	SN74141N	.99	SN74221N	1.25
SN7444N	1.10	SN74142N	3.25	SN74251N	.99
SN7445N	.89	SN74143N	3.49	SN74276N	1.95
SN7446N	.79	SN74144N	3.49	SN74279N	.79
SN7447N	.69	SN74145N	.79	SN74283N	1.49
SN7448N	.79	SN74147N	1.95	SN74284N	3.95
SN7450N	.20	SN74148N	1.29	SN74285N	3.95
SN7451N	.20	SN74150N	1.25	SN74365N	.69
SN7453N	.20	SN74151N	.69	SN74366N	.69
SN7454N	.20	SN74152N	.69	SN74367N	.69
SN7459A	.25	SN74153N	.79	SN74368N	.69
SN7460N	.20	SN74154N	1.25	SN74390N	1.49
SN7470N	.29	SN74155N	.79	SN74393N	1.49

74LS

74LS00	.29	74LS92	.75	74LS192	1.15
74LS01	.29	74LS93	.75	74LS193	1.15
74LS02	.29	74LS95	.99	74LS194	1.15
74LS03	.29	74LS96	1.15	74LS195	1.15
74LS04	.35	74LS107	.45	74LS197	1.19
74LS05	.35	74LS109	.45	74LS221	1.19
74LS08	.35	74LS112	.45	74LS240	1.49
74LS09	.35	74LS113	.49	74LS241	1.49
74LS10	.35	74LS114	.49	74LS242	1.49
74LS11	.39	74LS122	.89	74LS243	1.49
74LS12	.35	74LS123	1.25	74LS244	1.49
74LS13	.59	74LS125	.59	74LS245	2.95
74LS14	.99	74LS126	.59	74LS247	1.19
74LS15	.35	74LS132	.99	74LS248	1.19
74LS20	.35	74LS133	.89	74LS249	1.19
74LS21	.35	74LS136	.49	74LS251	.99
74LS22	.35	74LS138	.89	74LS253	.99
74LS26	.35	74LS139	.89	74LS257	.89
74LS27	.35	74LS151	.89	74LS258	.69
74LS28	.35	74LS153	.89	74LS260	.69
74LS30	.35	74LS154	1.75	74LS266	.69
74LS32	.35	74LS155	.89	74LS273	1.95
74LS33	.59	74LS156	.89	74LS279	.89
74LS37	.45	74LS157	.89	74LS283	.89
74LS38	.39	74LS158	.89	74LS290	.99
74LS40	.35	74LS160	1.15	74LS293	.99
74LS42	.89	74LS161	1.15	74LS298	1.25
74LS47	.89	74LS162	1.15	74LS352	1.29
74LS48	1.15	74LS163	1.15	74LS353	1.29
74LS49	1.15	74LS164	1.15	74LS365	.69
74LS51	.35	74LS165	1.15	74LS366	.69
74LS54	.35	74LS168	1.19	74LS367	.69
74LS55	.35	74LS169	1.19	74LS368	.69
74LS73	.45	74LS170	1.95	74LS373	1.95
74LS74	.45	74LS173	.99	74LS374	1.95
74LS75	.59	74LS174	.99	74LS375	.89
74LS76	.45	74LS175	.99	74LS386	.69
74LS78	.49	74LS181	2.95	74LS393	2.49
74LS83	.89	74LS190	1.25	74LS399	2.49
74LS85	1.25	74LS191	1.25	74LS670	2.49
74LS86	.49			81LS95	1.95
74LS90	.69			81LS97	1.95

74S/PROMS*

74S00	.35	74S124	2.95	74S243	2.25
74S02	.35	74S133	.45	74S244	2.25
74S03	.35	74S134	.50	74S251	.99
74S04	.45	74S135	.89	74S253	.99
74S05	.45	74S136	1.39	74S257	.99
74S08	.40	74S138	.99	74S258	.99
74S09	.40	74S139	.99	74S260	.79
74S10	.35	74S140	.55	74S280	2.25
74S11	.35	74S151	.99	74S287*	1.95
74S15	.35	74S153	.99	74S288*	1.95
74S20	.35	74S157	.99	74S373	2.49
74S22	.35	74S158	.99	74S374	2.49
74S30	.35	74S160	2.49	74S387*	1.95
74S32	.45	74S174	1.25	74S471*	5.95
74S38	.89	74S175	1.25	74S472*	5.95
74S40	.40	74S188*	1.95	74S473*	5.95
74S51	.35	74S194	1.49	74S474*	7.95
74S64	.40	74S195	1.49	74S475*	7.95
74S65	.40	74S196	1.49	74S570*	4.49
74S74	.55	74S240	2.25	74S571*	4.49
74S86	.55	74S241	2.25	74S572*	5.95
74S112	.55	74S242	2.25	74S573*	5.95
74S113	.55			74S940	1.95
74S114	.55			74S941	1.95

CA–LINEAR

CA3010H	.99	CA3060N	3.25	CA3089N	3.75
CA3013H	2.15	CA3080H	1.25	CA3096N	3.95
CA3023H	3.25	CA3081N	2.00	CA3130H	1.39
CA3035H	2.49	CA3082N	2.00	CA3140H	1.25
CA3039H	1.35	CA3083N	1.60	CA3160H	1.25
CA3046N	1.30	CA3086N	.85	CA3401N	.59
CA3059N	3.25			CA3600N	3.50

CD–CMOS

CD4000	.39	CD4041	1.49	CD 4098	2.49
CD4001	.39	CD4042	.99	CD4506	.75
CD4002	.39	CD4043	.89	CD4507	.99
CD4006	1.19	CD4044	.89	CD4508	3.95
CD4007	.25	CD4046	1.79	CD4510	1.39
CD4009	.49	CD4047	2.50	CD4511	1.29
CD4010	.49	CD4048	1.35	CD4512	1.49
CD4011	.39	CD4049	.49	CD4514	3.95
CD4012	.25	CD4050	.69	CD4515	2.95
CD4013	.49	CD4051	1.19	CD4516	1.49
CD4014	1.39	CD4052	1.19	CD4518	1.79
CD4015	1.19	CD4053	1.19	CD4519	.89
CD4016	.59	CD4056	2.95	CD4520	1.29
CD4017	1.19	CD4059	9.95	CD4526	1.79
CD4018	.99	CD4060	1.49	CD4528	1.79
CD4019	.49	CD4066	.79	CD4529	1.95
CD4020	1.19	CD4068	.39	CD4543	2.79
CD4021	1.39	CD4069	.45	CD4562	11.95
CD4022	1.19	CD4070	.55	CD4566	2.79
CD4023	.29	CD4071	.49	CD4583	2.49
CD4024	.79	CD4072	.49	CD4584	.75
CD4025	.23	CD4073	.39	CD4723	1.95
CD4026	2.95	CD4075	.39	CD4724	1.95
CD4027	.69	CD4076	1.39	MC14409	17.95
CD4028	.89	CD4078	.55	MC14410	18.95
CD4029	1.49	CD4081	.39	MC14411	15.95
CD4030	.49	CD4082	.39	MC14412	15.95
CD4034	3.49	CD4093	.99	MC14419	7.95
CD4035	.99			MC14433	15.95
CD4040	1.49			MC14538	2.49
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MICROPROCESSOR COMPONENTS

STATIC RAMS

1101	256x1	(650ns)	1.49
2101 (8101)	256x4	(450ns)	3.95
2102	1024x1	(350ns)	1.75
21L02	1024x1	(450ns) L.P.	1.95
2111 (8111)	256x4	(450ns)	3.95
2112	256x4	(450ns) MOS	4.95
2114	1024x4	(450ns)	2.25 — 8/14.95
2114L	1024x4	(450ns) L.P.	2.49 — 8/16.95
2114-2	1024x4	(200ns)	2.49 — 8/16.95
2114L-2	1024x4	(200ns) L.P.	2.95 — 8/19.95
2141-3	4096x1	(150ns)	7.95
2147	4096x1	(70ns)	4.95
2148	1024x4	(70ns)	8.95
TMS4044	4096x1	(450ns)	5.95
TMS4045	1024x4	(450ns)	5.95
5101	256x4	(450ns) CMOS	7.95
MM5257(4044)	4096x1	(450ns)	6.40
HM6116-4	2048x8	(200ns) CMOS	9.95
HM6116LP-4	2048x8	(200ns) L.P.CMOS	9.95
7489 (3101)	16x4	(50ns)	1.75
74C920 (6551)	256x4	(250ns) CMOS	6.49
74C921	256x4	(250ns) CMOS	5.95
74C929 (6501)	1024x1	(250ns) CMOS	5.95
74C930 (6518)	1024x1	(250ns) CMOS	5.49
74S189(93405)	16x4	(35ns)	2.95
74S200(93410)	256x1	(80ns)	4.95
74S206(93411)	256x1	(60ns)	4.95
74S289 (3101)	16x4	(35ns)	2.49
82S10 (93415)	1024x1	(50ns) O.C.	4.95
82S25 (74S289)	16x4	(50ns) O.C.	3.49

EPROMS

1702A	256x8	(1µs)	4.95
2708	1024x8	(450ns)	4.95
TMS2516	2048x8	(450ns) 2716	6.95
TMS2532	4096x8	(450ns) NMC2532	9.95
TMS2564	8192x8	(450ns)	39.95
TMS2716	2048x8	(450ns) 3voltage	9.95
2716	2048x8	(450ns)	5.95
2732	4096x8	(450ns)	9.95
27580	1024x8	(450ns) single +5V	7.49
MM2764	8192x8	(450ns)	29.95
MM5203Q	256x8	(1us)	14.95

MICROPROCESSOR CHIPS

Z80 (780C)	CPU (MK3880N) (2MHz)	11.95
Z80A (780-1)	CPU (MK3880N-4) (4MHz)	13.95
CDP1802	CPU	19.95
2650	MPU	16.95
IDM2901AOC	CPU—4-bit slice(Com. Temp. Gr.)	19.95
MCS6502	MPU w/Clock (65K bytes mem.)	11.95
INS8035N-6	MPU—8-bit (6MHz)	7.95
INS8039N-6	CPU-Sgl. chip8-bit(128 bts. Ram)	9.95
INS8040N-6	CPU (256 bytes RAM)	24.95
INS8070N	CPU (64 bytesRAM)	24.95
INS8073N	CPU w/BasicMicro Interpreter	29.95
P8085	CPU	9.95
TMS9900JL	MPU — 16-bit	39.95

MICROPROCESSOR MANUALS

M-Z80	User Manual	7.50
M-CDP1802	UserManual	7.50
M-2650	User Manual	5.00

8800/8800 SUPPORT DEVICES

MC6800	MPU	7.95
MC6802CP	MPU with clock and RAM	14.95
MC6810API	128x8 StaticRAM	4.05
MC6821	Peripheral Inter. Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	17.95
MC6830L8	1024x8-bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	6.95
MC6852	SynchronousSerial Data Adapter	6.95
MC6860	0-600bps Digital MODEM	10.95
MC6862	2400bps Modulator	12.95
MC6880A	Quad3-state bus. trans. (MC8T26)	2.25

8080/8080A SUPPORT DEVICES

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DP8212	8-bitInput/Output	3.25
DP8214	Priority Interrupt Control	5.95
DP8216	Bi-Directional Bus Driver	3.49
DP8224	Clock Generator/Driver	3.95
DP8226	Bus Driver	3.49
DP8228	SystemController/Bus Driver	4.95
DP8238	SystemController	5.95
INS8243	I/O Expander for 48 Series	9.95
INS8250	Asynchronous Comm. Element	16.95
DP8251	Prog. Comm. I/O (USART)	6.95
DP8253	Prog. Interval Timer	8.95
DP8255	Prog. PeripheralI/O (PPI)	5.95
DP8257	Prog. DMA Control	9.95
DP8259	Prog. InterruptControl	9.95
DP8275	Prog. CRT Controller	39.95
DP8279	Prog. Keyboard/Display Interface	9.95
DP8303	System Timing Element	6.95
DP8304	8-bit Bi-Directional Receiver	3.95
DP8307	8-bit Bi-Directional Receiver	3.95
DP8308	8-bit Bi-Directional Receiver	3.95
DP8310	OctalLatched Peripheral Driver	5.25
DP8311	OctalLatched Peripheral Driver	5.25

DYNAMIC RAMS

1103	1024x1	(300ns)	.99
4027	4096x1	(250ns)	2.49
4116N-2	16,384x1	(150ns)	2.95 — 8/19.95
4116N-3	16,384x1	(200ns)	2.49 — 8/16.95
4116N-4	16,384x1	(250ns)	1.95 — 8/14.95
4164N-2	65,536x1	(200ns)	9.95
MM5261	1024x1	(300ns)	.49 — 8/1.95
MM5262	2048x1	(365ns)	.49 — 8/1.95
MM5270(MK4096)	4096x1	(250ns)	4.95
MM5280 (2107)	4096x1	(200ns)	4.95
MM5290-2	16,384x1	(150ns)	2.95 — 8/19.95
MM5290-3	16,384x1	(200ns)	2.49 — 8/16.95
MM5290-4	16,384x1	(250ns)	1.95 — 8/14.95
MM5298-3	8192x1	(200ns)	1.95

PROMS

74S188	32x8	PROMO.C. (6330-1)	1.95
74S287	256x4	PROM T.S. (6301-1)	1.95
74S288	32x8	PROM T.S. (6331-1)	1.95
74S387	256x4	PROMO.C. (6300-1)	1.95
74S471	256x8	PROM T.S. (6309-1)	5.95
74S472	512x8	PROM T.S. (6349-1)	5.95
74S473	512x8	PROM O.C. (6348)	5.95
74S474	512x8	PROMT.S. (OM87S296N)	7.95
74S475	512x8	PROM O.C. (6340)	7.95
74S478	1024x8	PROM T.S. (TBP28S86)	12.95
74S570	512x4	PROM O.C. (6305)	4.49
74S571	512x4	PROMT.S. (6306)	4.49
74S572	1024x4	PROMO.C. (6352)	5.95
74S573	1024x4	PROMT.S. (82S137)	5.95
82S23	32x8	PROM O.C. (27S18)	3.95
82S115	512x8	PROMT.S. (27S15)	9.95
82S123	32x8	PROM T.S. (27S19)	3.95
82S126	256x4	PROM O.C. (27S20)	3.95
82S129	256x4	PROMT.S. (27S21)	3.95
82S130	512x4	PROMO.C. (27S12)	5.95
82S185	2048x4	PROM T.S. (TBP24S81)	9.95
DM87S180N	1024x8	PROMO.C. (82S180)	9.95
DM87S181N	1024x8	PROM T.S. (82S181)	9.95
DM87S184N	2048x4	PROMO.C. (82S184)	9.95
DM87S185N	2048x4	PROMT.S. (82S185)	9.95
DM87S190N	2048x4	PROMO.C. (82S190)	19.95
DM87S191N	2048x8	PROMT.S. (82S191)	19.95

ROM'S

2513 (2140)	Character Generator (UpperCase)	9.95
2513 (3021)	Character Generator (LowerCase)	9.95

NMOS READ ONLY MEMORIES

MCM66710P	128x9x7 ASCII Shiftedw/Greek	13.50
MCM66740P	128x9x7 Math Symbol & Pictures	13.50
MCM66750P	128x9x7 Alpha. Control Char. Gen.	13.50

DATA ACQUISITION

DC10	Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	Floppy Disk Read AMP System	4.95
MC1408L7	7-bit D/A Converter(DAC0807LCN)	4.95
MC1408L8	8-bit D/A Converter(DAC0808LCN)	5.75
AF100-1CN	UniversalActive Filter 2.5%	5.95
AF121-1CJ	TouchToneLowBand Filter	19.95
AF122-1CJ	TouchTone HighBand Filter	19.95
LM308CH	Super Gain Op Amp	1.15
LM334Z	Constant Current Source	1.30
LM335Z	Temperature Transducer	1.40
LF356N	JFET Input Op Amp	1.10
LF398N	Sample & Hold Amplifiers	3.95
LM399H	Temp.Comp.Prec. Ref. (.5ppm/C°)	5.00
ADC0804LCN	8-bit A/D Converter (1 LSB)	4.95
DAC0806LCN	8-bit D/A Converter (0.78% Lin.)	2.25
ADC0809CCN	8-bit A/DConverter (8-Ch. Multi.)	5.25
ADC0817CCN	8-bit A/DConverter (16-Ch. Multi.)	10.95
DAC1000LCN	10-bitD/AConv. Micro.Comp.(0.05%)	13.95
DAC1008LCN	10-bit D/AConc. MicroComp.(0.20%)	8.95
DAC1020LCN	10-bit D/A Converter (0.05% Lin.)	8.49
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DAC1222LCN	12-bit D/A Converter (0.20% Lin.)	9.95
CD4051N	8-Channel Multiplexer	1.19
AY-5-1013	30K BAUDUART	6.95

SPECIAL FUNCTION

DS0025CN	Dual MOS Clock Driver (5MZ)	3.50
DS0026CN	Dual MOS Clock Driver (5MZ)	1.95
INS1771N-1	FloppyDisk Controller	24.95
INS2651N	CommunicationChip	19.95
MM58167N	Microprocessor RealTimeClock	8.95
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COP402N	Microcontroller w/64-digit RAM and Direct LED Drive	6.95
COP402MN	Microprocessorw/64-digit RAM & Direct LED Drive w/N Buss Int.	7.49
COP470N	32-seg. VACFluor. Drvr. (20-pinpkg.)	3.25

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	1-24	25-49	50-100
8 pin LP	.17	.16	.15
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

SOLDERTAIL (GOLD) STANDARD

	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
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7106CPL	3½ Digit A/D (LCD Drive)		16.95
7106EV/Kit*	IC, Circuit Board, Display		34.95
7107CPL	3½ Digit A/D (LED Drive)		15.95
7107EV/Kit*	IC, Circuit Board, Display		29.95
7116CPL	3½ Digit A/D LCD Dis. HLD.		18.95
7117CPL	3½ Digit A/D LED Dis. HLD.		17.95
7201IDR	Low Battery Volt Indicator		2.25
7205IPG	CMOS LED Stopwatch/Timer		12.95
7205EV/Kit*	Stopwatch Chip, XTL		19.95
7206CJPE	Tone Generator		5.15
7206CEV/Kit*	Tone Generator Chip, XTL		12.95
7207AIPD	Oscillator Controller		6.50
7207AEV/Kit*	Freq. Counter Chip, XTL		13.95
7208IPI	Seven Decade Counter		17.95
7209IPA	Clock Generator		3.95
7215IPG	4 Func. CMOS Stopwatch CKT		13.95
7215EV/Kit*	4 Func. Stopwatch Chip, XTL		19.95
7216AIJI	8-Digit Univ. Counter C.A.		32.00
7216CIJI	8-Digit Freq. Counter C.A.		26.95
7216DIPI	8-Digit Freq. Counter C.C.		21.95
7217IJI	4-Digit LED Up/Down Counter CA		12.95
7217AIPI	4-Digit LED Up/Down Counter CC		14.95
7224IPL	LCD 4½ Digit Up Counter DRI		11.25
7226AIJL	8-Digit Univ. Counter		31.95
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7242IJA	CMOS Divide-by-256 RC Timer		2.05
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7260IJE	CMOS BCD Prog. Timer/Counter		5.25
7555IPA	CMOS 555 Timer (8 pin)		1.45
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7611BCPA	CMOS Op Amp Comparator	5MV	2.25
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7621BCPA	CMOS Dual Op Amp Comp.	5MV	3.95
7631CCPE	CMOS Tri Op Amp Comp.	10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp.	10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp.	10MV	7.50
7660CPA	Voltage Converter		2.95
8038CCPD	Waveform Generator		4.95
8048CCPE	Monolithic Logarithmic Amp		21.60
8069CCQ	50ppm Band—GAP Volt Ref. Diode		2.50
8211CPA	Volt Ref/Indicator		2.95
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74C14	.75	74C160	1.69	74C901	.69
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74C32	.39	74C163	1.69	74C912	10.95
74C42	1.39	74C164	1.59	74C915	1.69
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74C73	.79	74C174	1.39	74C922	5.49
74C74	.79	74C175	1.19	74C923	5.75
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74C90	1.29			80C97	.79
74C93	1.29				

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LM312H	2.49	LM382N	1.79	LM1877N-9	3.25
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LM317K	3.95	LM387N	1.45	LM2002T	1.49
LM318CN	1.95	LM389N	1.35	LM2877P	2.05
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LM320K-12	1.35	LM399H	5.00	LM3189N	2.95
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LM320T-5	1.25	TL496CP	1.75	LM3905CN	1.25
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10 pf	.08	.06	.05	.001µF	.08	.06	.05
22 pf	.08	.06	.05	.0047µF	.08	.06	.05
47 pf	.08	.06	.05	.01µF	.08	.06	.05
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.08	.06	.05	.047µF	.09	.07	.06
470 pf	.08	.06	.05	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022mf	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (Solid) CAPACITORS

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.15/35V	.39	.34	.29	2.2/35V	.51	.45	.34
.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.55
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.55

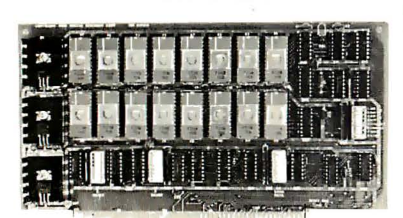
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Axial	1-99	100-499	500+	Radial	1-99	100-499	500+
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3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

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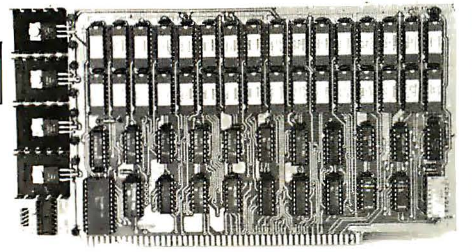
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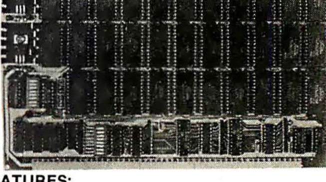


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* Fully supports Extended Addressing.
* 64K draws only approximately 500 MA.
* 200 NS RAMs are standard. (TOSHIBA makes TMM 2016s as fast as 100 NS. FOR YOUR HIGH SPEED APPLICATIONS.)
* Board is configured as 3-16K blocks and 8-2K blocks (within any 64K block) for maximum flexibility.
* 2716 EPROMs may be installed anywhere on Board.
* Top 16K may be disabled in 2K blocks to avoid any I/O conflicts.
* One Board supports both RAM and EPROM.
* RAM supports 2MHZ operation at no extra charge!
* Board may be partially populated in 16K increments.

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COMPLETE KIT!
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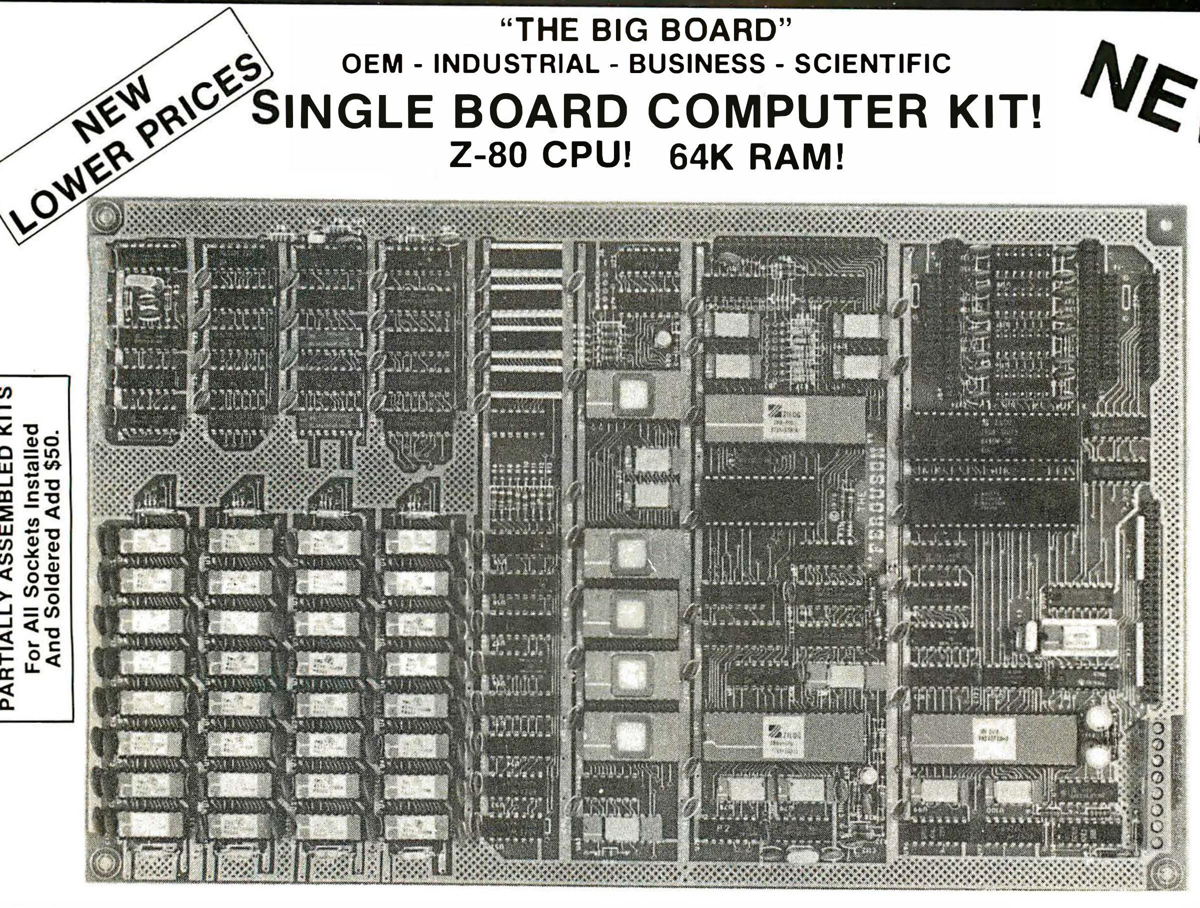
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SAME AS AN 8 IN. DRIVE.
REQUIRES: +5V @ 3 AMPS
+ - 12V @ .5 AMPS.

FULLY SOCKETED!

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Uses industry standard 4116 RAM'S. All 64K is available to the user. our VIDEO and EPROM sections do not make holes in system RAM. Also, very special care was taken in the RAM array PC layout to eliminate potential noise and glitches.

Z-80 CPU

Running at 2.5 MHZ. Handles all 4116 RAM refresh and supports Mode 2 INTERUPTS. Fully buffered and runs 8080 software.

SERIAL I/O (OPTIONAL)

Full 2 channels using the Z80 SIO and the SMC 8116 Baud Rate Generator. FULL RS232! For synchronous or asynchronous communication. In synchronous mode, the clocks can be transmitted or received by a modem. Both channels can be set up for either data-communication or data-terminals. Supports mode 2 Int. Price for all parts and connectors: $49

BASIC I/O

Consists of a separate parallel port (Z80 PIO) for use with an ASCII encoded keyboard for input. Output would be on the 80 x 24 Video Display.

24 x 80 CHARACTER VIDEO

With a crisp, flicker-free display that looks extremely sharp even on small monitors. Hardware scroll and full cursor control. Composite video or split video and sync. Character set is supplied on a 2716 style ROM, making customized fonts easy. Sync pulses can be any desired length or polarity. Video may be inverted or true. 5 x 7 Matrix - Upper & Lower Case

FLOPPY DISC CONTROLLER

Uses WD1771 controller chip with a TTL Data Separator for enhanced reliability. IBM 3740 compatible. Supports up to four 8 inch disc drives. Directly compatible with standard Shugart drives such as the SA800 or SA801. Drives can be configured for remote AC off-on. Runs CP/M* 2.2.

TWO PORT PARALLEL I/O (OPTIONAL)

Uses Z-80 PIO. Full 16 bits, fully buffered, bi-directional. User selectable hand shake polarity. Set of all parts and connectors for parallel I/O: $19.95

REAL TIME CLOCK (OPTIONAL)

Uses Z-80 CTC. Can be configured as a Counter on Real Time Clock. Set of all parts: $9.95

BLANK PC BOARD — $149

The blank Big Board PC Board comes complete with full documentation (including schematics), the character ROM, the PFM 3.3 MONITOR ROM, and a diskette with the source of our BIOS, BOOT, and PFM 3.3 MONITOR.

CP/M* 2.2 FOR BIG BOARD

The popular CP/M* D.O.S. to run on Big Board is available for $159.00.

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PFM 3.3 2K SYSTEM MONITOR

The real power of the Big Board lies in its PFM 3.3 on board monitor. PFM commands include: Dump Memory, Boot CP/M*, Copy, Examine, Fill Memory, Test Memory, Go To, Read and Write I/O Ports, Disc Read (Drive, Track, Sector), and Search. PFM occupies one of the four 2716 EPROM locations provided.
Z-80 Is a Trademark of Zilog.

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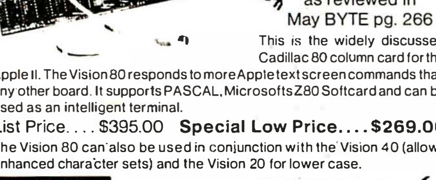
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Vista COMPUTER



Vision 80

as reviewed in May BYTE pg. 266

This is the widely discussed Cadillac 80 column card for the Apple II. The Vision 80 responds to more Apple text screen commands than any other board. It supports PASCAL, Microsofts Z80 Softcard and can be used as an intelligent terminal.

List Price.... $395.00 **Special Low Price.... $269.00**

The Vision 80 can also be used in conjunction with the Vision 40 (allows enhanced character sets) and the Vision 20 for lower case.

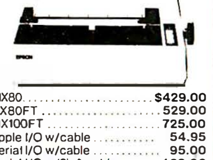
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- **EPSON TO IBM CABLE** 49

EPSON



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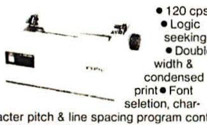
	LIST	ACP
ES100RO Comp. Print.	$1690	$1395
ES100 Typewriter Print	1195	1050
GQ10 Apple I/O card	349	169
GQ11 Other I/O's	349	299
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Apple Cable	19.95
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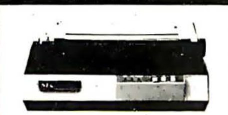
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8012C 12" B/W	250	219
8012CX 12" Green	260	229
6013 13" Color	470	422
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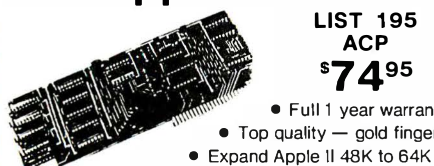
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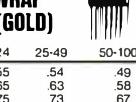
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16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.29	.27	.24
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28 pin LP	.45	.44	.43
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LM339N	.95	CA3080T	1.29
LM340K-XX*	1.75	CA3081N	1.69
LM340T-XX*	1.25	CA3082N	1.69
LM340H-XX*	1.25	CA3083N	1.55
LM344H	1.95	CA3086N	.80
LM348N	1.20	CA3089N	2.99
LM350K	5.60	CA3096N	3.49
LM358CN	.98	CA3097N	1.99
LM360N	1.49	CA3130T	1.30
LM372N	1.95	CA3140T	1.19
LM376N	3.75	CA3146N	2.49
LM377N	2.75	CA3160T	1.19
LM380CN/N	1.25	CA3190N	1.95
LM381N	1.79	CA3410N	.59
LM383T	1.95	MC3423N	1.49
LM386N	1.25	MC3460N	3.95
LM387N	1.40	SG3524N	3.95
LM390N	1.95	CA3600N	3.39
NE531V/T	3.75	LM3900N	.59
NE555V	.39	LM3905N	1.19
NE556N	.98	LM3909N	.98
NE561T	19.95	LM3914N	3.75
NE565N/H	1.25	LM3915N	3.95
NE566H/V	1.75	LM3916N	3.75
NE567V/H	1.50	RC4131N	2.95
NE592N	2.75	RC4136N	1.10
LM702H	1.99	RC4151N	3.70
LM709N/H	.29	RC4194TK	4.95
LM710N/H	.75	RC4195TK	5.40
LM711N/H	.39	ULN2001	1.25
LM715N	1.95	ULN2003	1.50
LM723N/H	.65	SN75450N	.59
LM733N/H	.98	SN75451N	.35
LM739N	1.15	SN75452N	.49
LM741CN/H	.33	SN75453N	.49
LM741CN-14	.19	SN75454N	.49
LM747N/H	.75	SN75491N	.89
LM748N/H	.39	SN75492N	.89
LM760CN	2.95	SN75493N	.89
LM1310N	1.90	SN75494N	.89
MC1330	1.95	TL494CN	4.20
MC1350	1.95	TL496CP	1.65
MC1358	1.75		

74S00

74S00	$.39	74S124	3.69	74S244	$2.99
74S02	.43	74S133	.54	74S251	1.35
74S03	.45	74S134	.66	74S253	1.35
74S04	.52	74S135	1.15	74S257	1.29
74S05	.52	74S136	1.69	74S258	1.29
74S08	.49	74S138	1.29	74S260	.75
74S09	.49	74S139	1.29	74S280	2.79
74S10	.42	74S140	.73	74S287	2.99
74S11	.42	74S151	1.29	74S288	2.55
74S15	.42	74S153	1.29	74S373	3.10
74S20	.42	74S157	1.29	74S374	3.10
74S22	.42	74S158	1.29	74S387	2.75
74S30	.42	74S160	2.79	74S471	7.95
74S32	.49	74S174	1.49	74S472	7.95
74S38	1.19	74S175	1.49	74S473	7.95
74S40	.49	74S188	2.69	74S474	9.95
74S51	.42	74S194	1.69	74S475	9.95
74S64	.46	74S195	1.89	74S570	5.75
74S65	.46	74S196	1.89	74S571	5.75
74S74	.69	74S240	2.75	74S572	8.95
74S86	.72	74S241	2.75	74S573	8.95
74S112	.72	74S242	2.99	74S940	2.90
74S113	.72	74S243	2.99	74S941	2.90
74S114	.72				

7400

7400	$.19	7475	$.38	74161	$.88
7401	.22	7476	.34	74162	.89
7402	.22	7479	4.60	74163	.87
7403	.22	7480	.49	74164	.87
7404	.22	7482	.95	74165	.87
7405	.23	7483	.55	74166	1.20
7406	.35	7485	.65	74167	1.95
7407	.35	7486	.35	74170	1.69
7408	.26	7489	1.75	74172	4.75
7409	.23	7490	.39	74173	.79
7410	.22	7491	.57	74174	.89
7411	.29	7492	.45	74175	.85
7412	.29	7493	.45	74176	.75
7413	.39	7494	.69	74177	.75
7414	.59	7495	.65	74179	1.34
7416	.29	7496	.69	74180	.75
7417	.29	7497	2.90	74181	1.75
7420	.22	74100	2.90	74182	.75
7421	.35	74107	.32	74184	2.25
7422	.29	74109	.37	74185	2.25
7423	.29	74116	1.95	74186	9.95
7425	.29	74121	.29	74188	3.90
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.59	74191	1.15
7429	.45	74125	.39	74192	.85
7430	.23	74126	.44	74193	.85
7432	.29	74128	.59	74194	.85
7437	.25	74132	.69	74195	.68
7438	.29	74136	.75	74196	.85
7439	.29	74139	.95	74197	.85
7440	.19	74141	.79	74198	1.39
7441	.79	74142	2.95	74199	1.39
7442	.57	74143	2.95	74221	1.19
7443	.95	74144	2.95	74251	.95
7444	.95	74145	.62	74273	1.05
7445	.79	74147	1.95	74276	1.89
7446	.79	74148	1.20	74279	.75
7447	.65	74150	1.09	74283	1.40
7448	.79	74151	.67	74284	3.90
7450	.19	74152	.67	74285	3.90
7451	.19	74153	.67	74290	1.25
7453	.19	74154	1.19	74298	.95
7454	.19	74155	.78	74365	.68
7459	.25	74156	.78	74366	.68
7460	.23	74157	.69	74367	.68
7470	.29	74158	1.65	74368	.68
7472	.29	74159	2.49	74390	1.45
7473	.34	74160	.88	74393	1.90
7474	.34			74490	1.90

74LS00

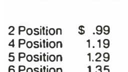
74LS00	$.26	74LS113	$.43	74LS245	$2.20
74LS01	.28	74LS114	.43	74LS247	1.10
74LS02	.28	74LS122	.55	74LS248	1.10
74LS03	.28	74LS123	1.19	74LS249	1.19
74LS04	.35	74LS124	1.35	74LS251	1.40
74LS05	.28	74LS125	.89	74LS253	1.40
74LS08	.28	74LS126	.52	74LS257	.65
74LS09	.35	74LS132	.79	74LS258	.98
74LS10	.28	74LS136	.49	74LS259	2.95
74LS11	.39	74LS138	.85	74LS260	.65
74LS12	.33	74LS139	.65	74LS261	2.49
74LS13	.47	74LS145	1.25	74LS266	.59
74LS14	.95	74LS148	1.49	74LS273	1.75
74LS15	.33	74LS151	.79	74LS275	4.40
74LS20	.26	74LS153	.79	74LS279	.59
74LS21	.33	74LS154	1.70	74LS283	.99
74LS22	.33	74LS155	1.19	74LS290	.99
74LS26	.33	74LS156	.99	74LS293	.99
74LS27	.33	74LS157	.85	74LS295	1.10
74LS28	.33	74LS158	.75	74LS298	1.19
74LS30	.26	74LS160	1.05	74LS324	1.75
74LS32	.33	74LS161	1.15	74LS347	1.95
74LS33	.55	74LS162	1.05	74LS348	1.95
74LS37	.45	74LS163	1.05	74LS352	1.19
74LS38	.39	74LS164	1.19	74LS353	1.19
74LS40	.26	74LS165	.89	74LS363	1.49
74LS42	.79	74LS166	2.48	74LS365	.69
74LS47	.79	74LS168	1.15	74LS366	.69
74LS48	.95	74LS169	1.15	74LS367	.69
74LS51	.26	74LS170	1.99	74LS368	.69
74LS54	.29	74LS173	.89	74LS373	1.89
74LS55	.29	74LS174	.89	74LS374	1.89
74LS73	.45	74LS175	.89	74LS375	.69
74LS74	.42	74LS181	2.20	74LS377	1.95
74LS75	.59	74LS190	1.15	74LS385	1.95
74LS76	.45	74LS191	1.15	74LS386	.65
74LS78	.45	74LS192	.98	74LS390	1.95
74LS83A	.79	74LS193	.98	74LS393	1.95
74LS85	1.19	74LS194	1.15	74LS395	1.70
74LS86	.45	74LS195	.95	74LS399	2.35
74LS90	.57	74LS196	.89	74LS424	2.95
74LS92	.75	74LS197	.89	74LS668	1.75
74LS93	.75	74LS221	1.15	74LS670	2.29
74LS95	.88	74LS240	1.69	81LS95	1.69
74LS96	.98	74LS242	1.69	81LS96	1.69
74LS107	.45	74LS243	1.69	81LS97	1.89
74LS109	.45	74LS244	1.49	81LS98	1.69
74LS112	.43				

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4008	1.39	4044	.85	14408	12.95
4009	.45	4046	1.75	14409	12.95
4010	.45	4047	1.25	14410	12.95
4011	.35	4048	.99	14412	12.95
4012	.25	4049	.45	14415	8.95
4013	.45	4050	.69	14419	4.95
4014	1.39	4051	1.10	4501	.39
4015	1.15	4052	1.10	4502	1.65
4016	.59	4053	1.10	4503	.69
4017	1.19	4055	3.95	4505	8.95
4018	.89	4056	2.95	4506	.75
4019	.45	4059	9.25	4507	.95
4020	1.10	4060	1.39	4508	3.75
4021	1.19	4066	.75	4510	1.19
4022	1.15	4069	.35	4511	1.19
4023	.29	4070	.49	4512	1.39
4024	.75	4071	.35	4515	2.75
4025	.25	4072	.35	4516	1.45
4027	.65	4073	.35	4518	1.39
4028	.85	4075	.35	4520	1.25
4029	1.29	4076	1.29	4555	4.95
4030	.45	4077	.35	4556	.99
4031	3.25	4078	.35	4566	2.25
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4034	3.25	4082	.35	80C97	1.25
4035	.95	4085	1.95		

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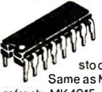
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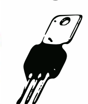
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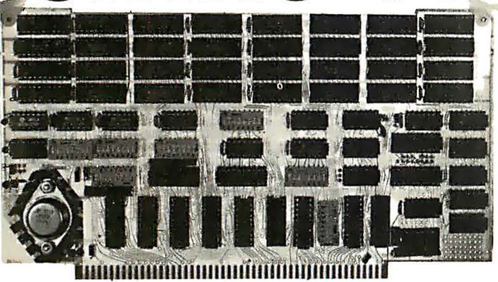
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VDM-121 20 lbs.



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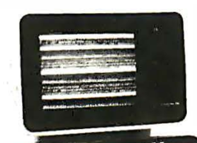
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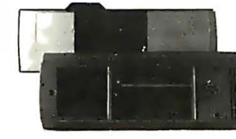
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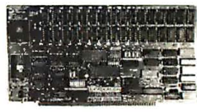


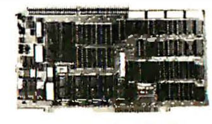
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Calender/Clock. Bat. back-up 7424	99
Parallel Interface 7720A	99
Programable Timer 7740A	99
Analog/Digital converter 7470A	99
MICROSOFT PRODUCTS	
Apple to Z-80 CPU card	379
D.C. HAYES PRODUCTS	
Micromodem for Apple	319
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INTERACTIVE STRUCTURES	
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SSM MICROCOMPUTER	
Dual serial parallel interface AIO	
SORRENTO VALLEY ASSOCIATES	
8" floppy controller (Pascal)	360

S-100 BOARDS

Assembled • Tested • Burned-in





CPU BOARDS		
Calif. Computer 2810A Z-80 DMA. 4MHz	BDC-C2810	$250
Godbout Z-80 24 bit. 4MHz	BDC-GZ80	239
Godbout 8085/8088 dual 16 bit processor	BDC-G88	375
Measurement Systems Z-80 4 serial 2 parallel real time clock. 8 vector	BDC-MZ80	395
SD Systems SBC-200 Z-80 with serial & parallel I/O ports	BDC-SBC2	385
Teletek FDC-1 single board CPU & floppy disk controller plus I/O	BDC-FDC1	695
MAINFRAMES		
Calif. Computer 2200A 12 slot & power supply	ENM-C2200	
TEI 12 slot table	ENM-T12	
TEI 22 slot table	ENM-T22	
Godbout mainfrm.	ENM-GMF	
MEMORY BOARDS		
Calif. Computer 2065A 64K dyamic memory	BDM-C2065	
Calif. Computer 2016 16K static memory	BDM-C2016	259
Calif. Computer 2032 32K static memory	BDM-C2032	585
Godbout Ram 17 64K static memory 16 bit	BDM-G17	1025
SD Systems Expandoram II 16K dynamic	BDM-EX16	295
64K dynamic	BDM-EX64	375
Measurement Systems DMB6400 for Alpha Micro	BDM-M6400	685
EPROM BOARDS		
Digit 1 Research 32K, 2716 proms extra	BDM-DP32	99
SD Systems Prom-100 programmer	BDM-P100	250
FLOPPY DISK CONTROLLER		
Calif. Computer 2422A with 2.2 CPM	BDF-C2422	329
Godbout "Disk One" features the NEC 765 controller. DMA arbitration	BDF-GD1	395
Measurement Systems 765 chip. single & double density. Error recover	BDF-MF	419
SD Systems Versafloppy II double density	BDF-VF2	419
Tarbell D/D	BDF-TF2	419
Morrow Design Disk Jockey I single density	BDF-DJ1	195
Morrow Design Disk Jockey II double density	BDF-DJ2	345
INTERFACE BOARDS		
Calif. Computer 2718 I/O 2 serial/2 par'l	BDT-C2718	
Morrow Designs Switchboard 2 serial/4 parl	BDT-MSB	219
Morrow Designs Multiboard 3 serial/3P. +++	BDT-MMB	275
Godbout Interfacer One 2 serial/2 par'l	BDS-GE1	199
Godbout Interfacer Two 1 serial/3 par'l	BDS-GB2	199
SPECIALITY BOARDS		
QT Computer real time clock/calendar	BDS-QCK	135
Artec Elec. Wire wrap prototype board	BDS-AWW	25
Artec Elec. General Purpose proto board	BDS-AGP	25
Godbout Spectrum color board	BDS-GSC	295
D. C. Hayes S-100 Micromodem	BDS-HM1	350
Mullen Products extender board & logic probe kt	BDS-MTB1	49
Mullen Products Opto-contro board kit	BDS-MOC	139

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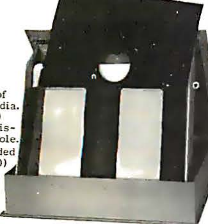
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DISKETTES

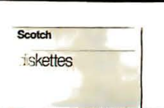
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Private labeled for California Digital by one of the most respected producers of magnetic media. Each diskette is certified double density at 40 tracks. To insure extended media life each diskette is manufactured with a reinforced hub-hole. *And of course, a plastic library case is included with every box of diskettes.* MMD-CD5(01)(10) Please specify computer or required sectors.

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5¼" DISKETTES WITH LIBRARY CASE

$26.50



Your Choice
SCOTCH MEMOREX VERBATIM

	Soft Sector	10 Sector	16 Sector	
SCOTCH	744-0	744-10	744-16	$26.50
MEMOREX	3401	3403	3405	26.50
VERBATIM	525-01	525-10	NA	26.50
DYSAN	104/1	107/1	NA	39.50
Single Side Double Density				
DYSAN	104/1D	107/1D	NA	45.00
Double Side Double Density				
SCOTCH	745-0	745-10	745-16	42.50
DYSAN	104/2D	107/2D	NA	49.50
DYSAN 96	204/2D	NA	NA	59.50

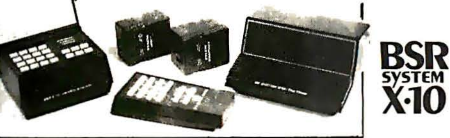
EIGHT INCH DISKETTES

Single Side Single Density			Single Side Double Density		
SCOTCH	740-0	29.50	SCOTCH	741-0	39.00
MEMOREX	3060	29.50	MEMOREX	3090	35.00
DYSAN	3740/1	39.50	DYSAN	3740/D	57.50
Thirty Two Sector			**Double side Double Density**		
SCOTCH	740-32	29.50	SCOTCH	743-0	47.50
			MEMOREX	3114	39.50
			DYSAN	3740/2D	65.00

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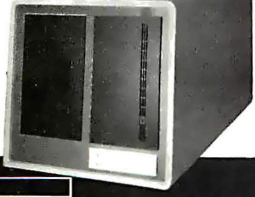
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$9.95	$13.95
4164 100+	2167 70ns.
16K DYNAMIC	**2716 EPROM**
$2.10	$4.95
4116 100·$1.85	100·$4.50 1K·$4.00



2732 EPROM SALE $7.95

STATIC

		ea.	32+	100+	1K+
21L02	1K	1.19	1.09	1.05	.99
2114	300ns.	2.95	2.75	2.50	1.99
4044-4	450ns.	4.50	4.19	4.00	3.75
4044-2	250ns.	4.95	4.65	4.50	4.25
6116	16k 24 pin	7.95	7.50	6.75	6.45
2167/6167	20 pin	11.95	10.75	9.65	9.25

EPROM

		ea.	32+	100+	1K+
2708	450ns.	3.95	3.50	3.25	3.00
2716	5V.	4.95	4.00	3.75	3.50
2716	tri-volt	8.50	7.95	7.65	7.25
2732	Intel/Hitac.	7.95	7.50	7.00	6.65
2532	Texas Inst	12.95	11.50	10.00	9.50
2764	64K Eprom	29.95	27.00	25.00	23.50



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The Universal Data Systems 103LP is switch selectable between answer and originate modes. Fully Bell 103 compatable. Directly connects to the new modular telephone jack. 100% powered from the telephoneline. No need to locate modem in proximity to A.C.power recepticle. MOD-103LP 2 pounds.

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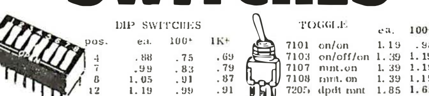
DIP SWITCHES

pos.	ea.	100+	1K+
4	.88	.75	.69
7	.99	.83	.79
8	1.05	.91	.87
12	1.19	.99	.91

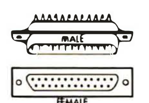
TOGGLE

		ea.	100+
7101	on/on	1.19	.98
7103	on/off/on	1.39	1.19
7107	mnt.on	1.39	1.19
7108	mnt. on	1.39	1.19
7205	dpdt mnt	1.85	1.65

CONNECTORS







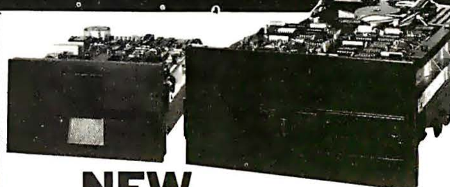
GOLD EDGE CONNECTORS

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Imsai solder .250" row	$2.95	$2.50
Imsai wire wrap (TI)	3.95	3.50
Sullins Hi-Rel. .250"	4.50	4.00
Sullins Hi-Rel. W/W	5.35	4.90
Sullins / Altair .140"	4.95	4.50
.156" Centers (standard)		
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36/72 Digital Group W/W	6.60	6.15
43/86 Motorola 6800S/T	6.60	6.15
43/86 Moto. 6800 W/W	7.00	6.85

INTEGRATED CIRCUIT SOCKETS

	Low Profile each	Low Profile 100+	Wire Wrap each	Wire Wrap 100+
8 pin	$.10	$.09	$.46	$.41
14 pin	.10	.09	.45	.41
16 pin	.12	.11	.50	.45
18 pin	.15	.13	.68	.61
24 pin	.26	.24	.94	.87
40 pin	.42	.40	1.60	1.47

"D" Type	each	10-24	25+
DE9P male	$1.60	$1.40	$1.30
DE9S female	2.25	2.00	1.90
DE hood	1.50	1.35	1.20
DA15P male	2.35	2.15	2.00
DA15S female	3.25	3.10	2.90
DA hood 2/P	1.60	1.35	1.30
DB25P male	2.50	2.35	2.25
DB25S female	3.35	3.15	3.05
DB hood 2/P	1.35	1.15	1.05
DC37P male	4.20	4.00	3.70
DC37S female	6.00	5.75	5.50
DC hood 2/P	2.25	2.00	1.75
DD50P male	5.50	5.10	4.75
DD50S female	9.40	8.60	8.00
DD50 hood 2/P	2.60	2.40	2.10
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20/40 TRS-80	5.65	5.05	4.70
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NEW OLIVETTI 801 Eight Inch Disk Drive $295

		ONE	TWO	TEN
★ OLIVETTI 801	single	$319	309	295
★ OLIVETTI 802/851	double	425	419	410
SHUGART 801/R	single	395	385	375
SHUGART 851/R	double	525	495	475
QUME DATA TRACK 8	double	525	495	475

★ The 8" Olivetti drives are aprox. ½" wider than the Shugarts.

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LM323K	4.95	LM394H	3.60	LM1307	.85	LM3914	3.95	75107	1.49	CA 3081	1.65
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7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
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78L12	.69	79L12	.79
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74LS04	.25	74LS92	.70	74LS174	.95	74LS353	1.55
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74LS08	.35	74LS95	.85	74LS181	2.15	74LS364	1.95
74LS09	.35	74LS96	.95	74LS189	9.95	74LS365	.95
74LS10	.25	74LS107	.40	74LS190	1.00	74LS366	.95
74LS11	.35	74LS109	.40	74LS191	1.00	74LS367	.70
74LS12	.35	74LS112	.45	74LS192	.85	74LS368	.70
74LS13	.45	74LS113	.45	74LS193	.95	74LS373	1.75
74LS14	1.00	74LS114	.50	74LS194	1.00	74LS374	1.75
74LS15	.35	74LS122	.45	74LS195	.95	74LS377	1.45
74LS20	.25	74LS123	.95	74LS196	.85	74LS378	1.18
74LS21	.35	74LS124	2.99	74LS197	.85	74LS379	1.35
74LS22	.25	74LS125	.95	74LS221	1.20	74LS385	1.90
74LS26	.35	74LS126	.85	74LS240	1.29	74LS386	.65
74LS27	.35	74LS132	.75	74LS241	1.29	74LS390	1.90
74LS28	.35	74LS136	.55	74LS242	1.85	74LS393	1.90
74LS30	.25	74LS137	.99	74LS243	1.85	74LS395	1.65
74LS32	.35	74LS138	.75	74LS244	1.29	74LS399	1.70
74LS33	.55	74LS139	.75	74LS245	1.90	74LS424	2.95
74LS37	.55	74LS145	1.20	74LS247	.75	74LS447	.37
74LS38	.35	74LS147	2.49	74LS248	1.25	74LS490	1.95
74LS40	.35	74LS148	1.35	74LS249	.99	74LS624	3.99
74LS42	.55	74LS151	.75	74LS251	1.30	74LS668	1.69
74LS47	.75	74LS153	.75	74LS253	.85	74LS669	1.89
74LS48	.75	74LS154	2.35	74LS257	.85	74LS670	2.20
74LS49	.75	74LS155	1.15	74LS258	.85	74LS674	9.65
74LS51	.25	74LS156	.95	74LS259	2.85	74LS682	3.20
74LS54	.35	74LS157	.75	74LS260	.65	74LS683	2.30
74LS55	.35	74LS158	.75	74LS266	.55	74LS684	2.40
74LS63	1.25	74LS160	.90	74LS273	1.65	74LS685	2.40
74LS73	.40	74LS161	.95	74LS275	3.35	74LS688	2.40
74LS74	.45	74LS162	.95	74LS279	.55	74LS689	2.40
74LS75	.50	74LS163	.95	74LS280	1.98	74LS783	24.95
74LS76	.40	74LS164	.95	74LS283	1.00	81LS95	1.69
74LS78	.50	74LS165	.95	74LS290	1.25	81LS96	1.69
74LS83	.75	74LS166	2.40	74LS293	1.85	81LS97	1.69
						81LS98	1.69

74S00

74S00	.44	74S85	2.39	74S169	5.44	74S274	19.95
74S02	.48	74S86	1.44	74S174	1.09	74S275	19.95
74S03	.48	74S112	1.59	74S175	1.09	74S280	2.90
74S04	.79	74S113	1.98	74S181	4.47	74S287	4.75
74S05	.79	74S114	1.50	74S182	2.95	74S288	4.45
74S08	.48	74S124	2.77	74S188	3.95	74S289	6.98
74S09	.98	74S132	1.24	74S189	14.95	74S301	6.95
74S10	.69	74S133	.98	74S194	2.95	74S373	3.45
74S11	.88	74S134	.69	74S195	1.89	74S374	3.45
74S15	.70	74S135	1.48	74S196	4.90	74S381	7.95
74S20	.68	74S138	1.08	74S197	4.25	74S387	5.75
74S22	.98	74S139	1.25	74S201	14.95	74S412	2.98
74S30	.48	74S140	1.45	74S225	8.95	74S471	9.95
74S32	.98	74S151	1.19	74S240	3.98	74S472	16.85
74S37	1.87	74S153	1.19	74S241	3.75	74S474	17.85
74S38	1.68	74S157	1.19	74S244	3.98	74S482	15.60
74S40	.44	74S158	1.45	74S251	1.90	74S570	7.80
74S51	.78	74S161	2.85	74S253	7.45	74S571	7.80
74S64	.79	74S162	3.70	74S257	1.39		
74S65	1.25	74S163	3.75	74S258	1.49		
74S74	.69	74S168	4.65	74S260	1.83		

IC SOCKETS

	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39

ST = SOLDERTAIL

8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80

WW = WIREWRAP

16 pin ZIF	6.75	call
24 pin ZIF	9.95	call

ZIF = TEXTOOL (Zero Insertion Force)

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RS232 MALE	3.25
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RS232 HOOD	1.25
S-100 ST	3.95
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6 POSITION	.90
7 POSITION	.95
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9334	2.50
9368	3.95
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9601	.75
9602	1.50
96S02	1.95

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ADC0817	10.95
DAC0800	4.95
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DAC1020	8.25
DAC1022	8.25
MC1408L8	4.95

7400

7400	.19	74136	.50
7401	.19	74141	.65
7402	.19	74142	2.95
7403	.19	74143	2.95
7404	.19	74145	.60
7405	.25	74147	1.75
7406	.29	74148	1.20
7407	.29	74150	1.35
7408	.24	74151	.65
7409	.19	74152	.65
7410	.19	74153	.55
7411	.25	74154	1.40
7412	.30	74155	.75
7413	.35	74156	.65
7414	.55	74157	.55
7416	.25	74159	1.65
7417	.25	74160	.85
7420	.19	74161	.70
7421	.35	74162	.85
7422	.29	74163	.85
7423	.29	74164	.85
7425	.29	74165	.85
7426	.29	74166	1.00
7427	.29	74167	2.95
7428	.45	74170	1.65
7430	.19	74172	5.95
7432	.29	74173	.75
7433	.45	74174	.89
7437	.29	74175	.89
7438	.29	74176	.89
7440	.19	74177	.75
7442	.49	74178	1.15
7443	.65	74179	1.75
7444	.69	74180	.75
7445	.69	74181	2.25
7446	.59	74182	.75
7447	.69	74184	2.00
7448	.69	74185	2.00
7450	.19	74132	.45
7451	.23	74190	1.15
7453	.23	74191	1.15
7454	.23	74192	.79
7460	.23	74193	.79
7470	.35	74194	.85
7472	.29	74195	.85
7473	.34	74196	.79
7474	.35	74197	.75
7475	.49	74198	1.35
7476	.35	74199	1.35
7480	.59	74221	1.35
7481	1.10	74246	1.35
7482	.95	74247	1.25
7483	.50	74248	1.85
7485	.65	74249	1.95
7486	.35	74251	.75
7489	4.95	74259	2.25
7490	.35	74265	1.35
7491	.40	74273	1.95
7492	.50	74276	1.25
7493	.49	74279	.75
7494	.65	74283	2.00
7495	.55	74284	3.75
7496	.70	74285	3.75
7497	2.75	74290	.95
74100	1.00	74293	.75
74107	.30	74298	.85
74109	.45	74351	2.25
74110	.45	74365	.65
74111	.55	74366	.65
74116	1.55	74367	.65
74120	1.20	74368	.65
74121	.29	74376	2.20
74122	.45	74390	1.75
74123	.55	74393	1.35
74125	.45	74425	3.15
74126	.45	74426	.85
74128	.55	74490	2.55

CMOS

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4001	.35	4531	.95
4002	.25	4532	1.95
4006	.95	4538	1.95
4007	.29	4539	1.95
4008	.95	4543	2.70
4009	.45	4555	.95
4010	.45	4556	.95
4011	.35	4581	1.95
4012	.25	4582	1.95
4013	.45	4584	.95
4014	.95	4585	.95
4015	.95	4702	12.95
4016	.45	74C00	.35
4017	1.15	74C02	.35
4018	.95	74C04	.35
4019	.45	74C08	.35
4020	.95	74C10	.35
4021	.95	74C14	1.50
4022	1.15	74C20	.35
4023	.35	74C30	.35
4024	.75	74C32	.50
4025	.35	74C42	1.75
4026	1.65	74C48	1.20
4027	.65	74C73	.65
4028	.80	74C74	.85
4029	.95	74C76	.80
4030	.45	74C83	1.95
4034	2.95	74C85	1.95
4035	.85	74C86	.95
4040	.95	74C89	4.50
4041	1.25	74C90	1.75
4042	.75	74C93	1.75
4043	.85	74C95	1.75
4044	.85	74C107	1.00
4046	.95	74C150	5.75
4047	.95	74C151	2.25
4049	.55	74C154	3.25
4050	.55	74C157	1.75
4051	.95	74C160	2.00
4053	.95	74C161	2.00
4060	1.45	74C162	2.00
4066	.75	74C163	2.00
4068	.40	74C164	2.00
4069	.35	74C165	2.00
4070	.35	74C173	2.00
4071	.30	74C174	2.25
4072	.30	74C175	2.25
4073	.30	74C192	2.25
4075	.30	74C193	2.25
4076	.95	74C195	2.25
4078	.30	74C200	5.75
4081	.30	74C221	2.25
4082	.30	74C373	2.75
4085	.95	74C374	2.75
4086	.95	74C901	.80
4093	.95	74C902	.85
4098	2.49	74C903	.85
4099	1.95	74C905	10.95
14409	12.95	74C906	.95
14410	12.95	74C907	1.00
14411	11.95	74C908	2.00
14412	12.95	74C909	2.75
14419	4.95	74C910	9.95
4502	.95	74C911	10.00
4503	.65	74C912	10.00
4508	1.95	74C914	1.95
4510	.95	74C915	2.00
4511	.95	74C918	2.75
4512	.95	74C920	17.95
4514	1.25	74C921	15.95
4515	2.25	74C922	5.59
4516	1.55	74C923	5.95
4518	1.25	74C925	6.75
4519	1.25	74C926	7.95
4520	1.25	74C927	7.95
4522	1.25	74C928	7.95
4526	1.25	74C929	19.95
4527	1.95	74C930	19.95

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MAN 74	.3"	CC	.99
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FND-500 (503)	.5"	CC	.99
FND-507 (510)	.5"	CA	.99

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Jumbo Green	.18	.15
Jumbo Yellow	.18	.15

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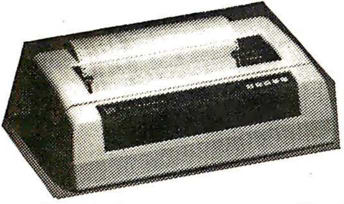
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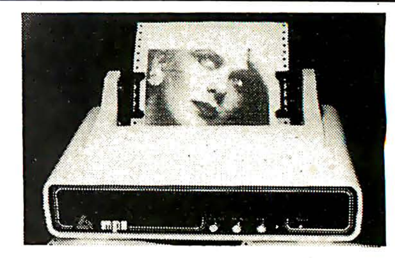
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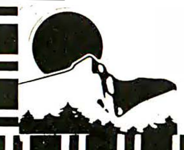
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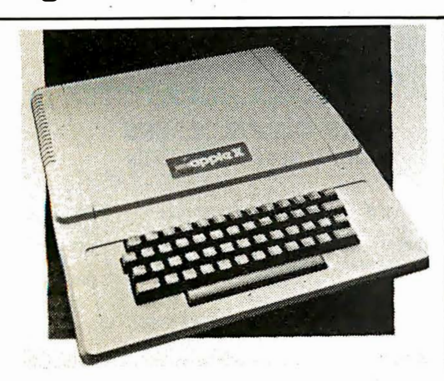
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NEC
PC-8000 Series Microcomputer



- Z-80A CPU 4 MHz
- 5 user programmable function keys
- 82 keys with numeric keypad
- 160 x 100 resolution
- 80 character screen

PC-800 1A Microcomputer w/32K RAM	$750.
PC-8012A I/O Unit with 32K RAM Expansion slots	480.
PC-8031A Dual Mini-Disk Drive Unit	750.

CENTRONICS AND OSBORNE CABLES

Centronics to Osborne 6 ft.	$30.
Centronics to Centronics 6 ft.	30.

RS232 CABLES

4 wire male-male 10 ft.	$25.
9 wire male-male 10 ft.	30.
4 wire male-female 10 ft.	25.
9 wire male-female 10 ft.	30.

RS-232 SWITCH BOX

RS232 Switch Box (Use 2 terminals or printers from one output port) ... 109.

VIDEO TERMS, MONITORS

Ampex Dialog 80	$995.
Ampex Dialog 30	795.
Televideo 920C	845.
Televideo 950	995.
SOROC IQ 120	499.
Zenith 12" Green	119.
NEC 12" Green	169.

SAVE $100s

COMREX
Video Monitors

CR-5500—*Monochrome Display Monitor—12" green screen, 80 char. wide x 24 rows.*
CR-5500 List $179 .... CALL

CR-6500 Color Display Monitor—*13" in-line color. Hi-Resolution 260H x 300V.*
CR-6500 List $445 .... CALL

CR-6600 Color Display Monitor—*13" in-line color with RGB signal for higher resolution graphics. 380H x 240V.*
CR-6600 List $619 .... CALL

FAN FOLD PAPER
(Prices F.O.B. S.P.)

9½x11-20#Bond White (2700 ct.)	$29.
14⅞x11-20#Bond White (2400 ct.)	37.
14⅞x11-20#Bond 1/2" Green Bar (2400 ct.)	37.

TERMS OF SALE: Cash, check, money order, bank wire transfer, credit card or purchase orders from qualified firms, and institutions. Please include telephone number with order and expiration date on credit card orders. California residents add 6% sales tax. Advertised prices are for prepaid orders. F.O.B. shipping point. Add 3% for shipping in U.S. Pricing and availability subject to change without notice.

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Computer Products



Circle 315 on inquiry card.

PRIORITY ONE ELECTRONICS

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1 ONE

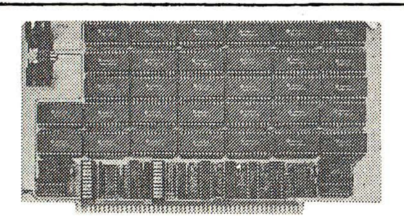
5 REASONS WHY YOU SHOULD SPEND AN EXTRA 5¢ WITH PRIORITY ONE

Some of you may have noticed that some other vendors have started to advertise CompuPro products. Frankly, we're amused that it has taken them this long to see that you want state-of-the-art IEEE/696 S-100 products. The discriminating user wants boards that meet the IEEE standard, not just any board with 100 pins that is obsolete before it is sold. We've known this for years; that is why we have continued to grow while others have had to cut back. To attract your business, they try to copy us and cut the price, often by as little as five cents. Rather than cut price, we offer the best combination of price, performance, and support in the business. We at Priority One are proud of what we offer for that extra five cents. Priority One Electronics is more than just a computer store or mail order house — we're an Authorized CompuPro Systems Center. Priority One is the first place you should turn to for business, scientific, and industrial computing solutions. Here are just five examples of what that extra five cents buys:

- As an Authorized Systems Center, we provide custom system integration from board level components
- We maintain full documentation on all CompuPro hardware and software
- We attend and hold periodic factory training seminars on CompuPro products
- We have factory trained Sales Engineers available to answer your questions after the sale is made. When you call Priority One, you'll speak with a professional, not an answering machine or answering service
- We buy directly from the factory, not from two step distributors, so we're always first to receive new products and new information about enhancements for existing products. When we buy direct, we we buy in volume. Whether you need one board or one hundred, we can usually deliver from stock

When you're ready for professional level, state-of-the-art microcomputing, turn to Priority One, the world's largest Authorized CompuPro Systems Center. We're ready for you.

☆☆☆☆☆☆☆☆☆☆☆☆



CMOS STATIC RAM

For a complete analysis of the advantages of CMOS memory, see the "Product Description" on page 416 of the January Issue of BYTE.

RAM 17 - 64K CMOS STATIC RAM

RAM 17, 10 MHz, 2 Watt, DMA Compatible 24 Bit Addressing

Part No.	Description	List Price	Our Price
BHGBT175A64	64K A&T	$599.00	$550.00
BHGBT175C64	64K CSC	$750.00	$699.00

RAM 16 - 32K x 16 BIT CMOS STATIC RAM

8 and/or 16 Bit

(816) RAM 16 10 MHz, 32K x 16 or 64K x 8 IEEE/696 16 Bit 2 Watt, 24 Bit Addressing

BHGBT180A	64K A&T	$650.00	$599.00
BHGBT180C	64K CSC	$750.00	$899.00

NEW! RAM 21 - 128K STATIC RAM (816)

(816) RAM 21 12MHz, 128K x 8 or 64K x 16 IEEE/696 8 or 16 Bit 1.2 Amps, 24 Bit Addressing

BHGBT190A	128K A&T	$1695.00	$995.00
BHGBT190C	128K CSC	$1895.00	$1795.00

M-DRIVE SOLID STATE DISK DRIVE, 3500% FASTER!

Not Really, But the Next Best Thing for CompuPro 8085/88 Users. Call for Details on M-Drive.

M-Drive requires a 6MHz CPU 8085/88 dual processor, Disk 1 DMA disk controller and System Suport 1 Multifunction Board

BHGBTM0128KA	128K of A&T memory & M-Drive Software	$1198.00
BHGBTM0128KC	128K of CSC memory & M-Drive Software	$1398.00
BHGBTM0256KA	256K of A&T memory & M-Drive Software	$2395.00
BHGBTM0256KC	256K of CSC memory & M-Drive Software	$2795.00

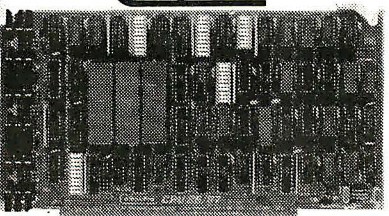
STATIC MEMORY BOARDS

RAM 20 - 32K STATIC RAM

RAM 20 10 MHz, 4K byte block disable, bank select or 24 bit addressing available 8, 16, 24 or 32K

BHGBT164AA8	8K A&T	$210.00	$190.00
BHGBT164AC8	8K CSC	$280.00	$260.00
BHGBT164AA16	16K A&T	$285.00	$260.00
8HGBT164AC16	16K CSC	$355.00	$325.00
BHGBT184AA24	24K A&T	$355.00	$325.00
BHGBT184AC24	24K CSC	$425.00	$385.00
BHGBT164AA32	32K A&T	$425.00	$385.00
BHGBT164AC32	32K CSC	$495.00	$450.00

CompuPro™



NEW!

CPU BOARDS

CO-PROCESSOR 8086/8087 (816)

16 bit 8 or 10 MHz 8086 CPU with sockets for 8087 and 80130

Part No.	Description	List Price	Our Price
BHGBT186A	A&T 8MHz 8086 only	$695.00	$ 625.00
BHGBT186C	CSC 10MHz 8086 only	$850.00	$765.00
BHGBT186A87	A&T with 8087 option*	$1295.00	$1225.00
BHGBT186C87	CSC with 8087 option*	$1550.00	$1456.00

*8087 Limits clock speed to 5MHz

DUAL PROCESSOR 8085-8088

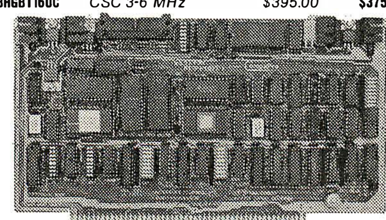
6 or 8 MHz Provides true 16 Bit Power with a standard 8 bit S-100 bus

BHGBT1612A	A&T 6Mhz	$425.00	$399.00
BHGBT1612C	CSC 6/8 MHz	$525.00	$498.00

CPU-Z Z80 CPU

2/4 MHz Z80 CPU 24 Bit Addressing

BHGBT160A	A&T	$295.00	$280.00
BHGBT160C	CSC 3-6 MHz	$395.00	$375.00



I/O BOARDS

SYSTEM SUPPORT 1 MULTIFUNCTION BOARD

Serial port (software prog. baud), 4K EPROM or RAM provision, 15 levels of interrupt, real time clock, optional math processor

Part No.	Description	List Price	Our Price
BHGBT162A	Assembled & Tested	$399.00	$360.00
BHGBT162C	CSC	$495.00	$460.00
BHGBT8231	Math Chip		$195.00
BHGBT8232	Math Chip		$195.00
BHGBT162AM1	A&T with 8231 Math Chip		$555.00
BHGBT162CM1	CSC w/8231 Math Chip		$655.00
BHGBT162AM2	A&T w/8232 Math Chip		$555.00
BHGBT162CM2	CSC w/8232 Math Chip		$655.00

MPX CHANNEL BOARD

I/O Multiplexer, using 8085A-2 CPU on board with 4K RAM

BHGBT166A4	Assembled & Tested	$495.00	$445.00
BHGBT166C4	CSC	$595.00	$535.00
	With 16K RAM		
BHGBT166A16	Assembled & Tested	$649.00	$585.00
BHGBT166C16	CSC	$749.00	$675.00

INTERFACER 1

Two Serial I/O

BHGBT133A	Assembled & Tested	$249.00	$219.00
BHGBT133C	CSC	$324.00	$298.00

INTERFACER 2

Three parallel, one serial I/O board

BHGBT150A	Assembled & Tested	$249.00	$219.00
BHGBT150C	CSC	$324.00	$289.00

INTERFACER 3

Eight channel multi-use serial I/O board

BHGBT1748A	Assembled & Tested	$699.00	$629.00
BHGBT1748C	CSC 200 hr. 8 Port	$849.00	$750.00
BHGBT1745A	Assembled & Tested	$599.00	$559.00
BHGBT1745C	CSC 200hr. 5 port	$699.00	$629.00

NEW!

INTERFACER 4

Three Serial, 1 Parallel, 1 Centronics Parallel

BHGBT187A	Assembled & Tested	$350.00	$315.00
BHGBT187C	CSC	$450.00	$415.00

SPECTRUM COLOR GRAPHICS

Color Graphics board with Parallel I/O

BHGBT144A	Assembled & Tested	$399.00	$349.00
BHGBT144C	CSC	$449.00	$339.00
BHGBT20	Sublogic Universal Graphics Interpreter Software		$35.00

S-100 MOTHERBOARDS

Active termination, 6-12-20 Slot

BHGBT153A	A&T 6 slot, 2 lbs.	$140.00	$128.00
BHGBT153C	CSC 6 slot, 2 lbs.	$190.00	$175.00
BHGBT154A	A&T 12 slot, 3 lbs.	$175.00	$155.00
BHGBT154C	CSC 12 slot, 3 lbs.	$240.00	$220.00
BHGBT155A	A&T 20 slot, 4 lbs.	$265.00	$235.00
BHGBT155C	CSC 20 slot, 4 lbs.	$340.00	$310.00

ACTIVE TERMINATOR

Allows older S-100 motherboards to run faster and quieter

BHGBT106A	Assembled & Tested		$59.50

CompuPro



DISK CONTROLLERS

DISK 1 FLOPPY CONTROLLER

Fast DMA, Soft Sector, Controls 8" or 5¼" Single or Double Density. OUR BEST!

BHPOBT171ACPM	A&T w/CP/M2.2 & BIOS	$670.00	$450.00
BHGBT171C	CSC	$595.00	$555.00
BHGBTCPM80*	CP/M 2.2 for Z80/8085 with manuals & BIOS 8" S/D disk		$175.00
BHGBTCPM86	CP/M for 8086 with manuals & BIOS 8" S/D disk		$300.00

NEW!

DISK 2/SELECTOR CHANNEL HARD DISK CONTROLLER

Fast DMA 2 board set. Controls 4 Shugart 4000 series or Fujitsu 2300 type drives. Includes CP/M 2.2®

BHGBT177A	Assembled & Tested	$795.00	$750.00
BHGBT177C	CSC	$895.00	$850.00



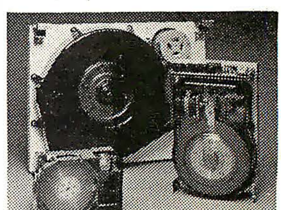
S-100 MAINFRAME

110V 60Hz CVT Mainframe uses famous 20 slot COMPUPRO Motherboard. 55 lbs.

BHGBTENC20RM	20 Slot Rack Mount	$895.00	$825.00
BHGBTENC200K	20 Slot Desk Top	$825.00	$760.00

Turn page for complete CompuPro Systems

MORROW DESIGNS



NEW!

S-100 5-26 MB HARD DISK SUBSYSTEMS

5 - 10 Mb DMA SUBSYSTEMS

Each subsystem includes DMA Hard Disk Controller, Seagate ST506 5 Mb or ST412 10 Mb 5¼" Hard Disk, Cabinet, power supply, CP/M™2.2 and Microsoft BASIC.

BHMOSOMAM*	Software supplied on 8" IBM 3740 disk with blank I/O and INSTALL program
BHMOSOMAM*2B	Software configured for Morrow DJ/2B controller and Mult I/O as console
BHMOSOMAM*DMA	Software configured for Morrow DJ/DMA controller and Mult I/O as console
BHMOSOMAM*NS	Software suplied on 5¼" 10 sector North Star disk with blank I/O and INSTALL Program

Replace * in above part numbers with **5** for 5Mb Subsystems or **10** for 10Mb Subsystems.

DISCUSM5	5Mb Subsystems	$2195.00	$1975.00
DISCUSM10	10Mb Subsystems	$3195.00	$2875.00

(order by part numbers listed above)

DISCUS HDC 20-26 Mb SUBSYSTEMS

Each subsystem includes HDCA3 I/O mapped controller, Shugart SA4008 14" 26Mb or Fujitsu 2308 8" 20Mb Hard Disk, cabinet, power supply, CP/M™2.2 & Microsoft BASIC.

BHMOSHDC20	Discus M20 A&T	$4495.00	$3394.00
BHMOSHDC26	Discus M26 A&T	$4495.00	$3394.00

WOW!

I/O BOARDS

MULTI I/O

Three Serial, Two Parallel

BHMOSMB3200	Assembled & Tested	$359.00	$329.00

SWITCHBOARD

Two serial I/O, four parallel I/O, one status port, one strobe port

BHMOSSB2411		$299.00	$269.00

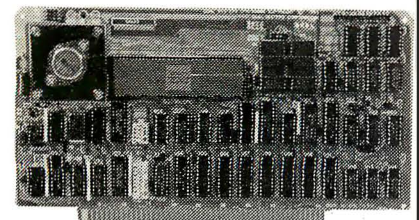
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★ Call for complete information on the new Micro Decision Z-80 based ★ computer breakthrough!

Circle 333 on inquiry card.

SUMMER CASH AND CARRY SALE





CPU BOARDS

CPU/68000 - 8MHz 68000 CPU

16 bit 68000 CPU with on board ROM containing MACSBUG Monitor or Motorola 68541 Memory Management Unit (MMU).

Part No.	Description	List Price	Our Price
BHDULCPU68000	A&T with Monitor	$1195.00	$1075.00
BHDULCPU68000M	A&T with MMU	$1495.00	$1395.00

MEMORY BOARDS

DMEM256KP-256K DYNAMIC MEMORY MODULE

256Kb with byte parity error detection for 8 or 16 bit computers

BHDULDMEM256	256K A&T	$1495.00	$1395.00

CMEM NONVOLATILE CMOS MEMORY

Nonvolatile CMOS memory with 3-10 year battery backup on board.

BHDULCMEM8	8K A&T	$695.00	$629.00
BHDULCMEM16	16K A&T	$795.00	$725.00
BHDULCMEM32	32K A&T	$995.00	$940.00

2716/2732 EPROM BOARD WITH 16 BIT DATA PATHS

Designed to hold 32Kb of 2716 type or 64Kb of 2732 type EPROMs, or ROMs for read only use with 16 bit CPU systems.

BHDULEPROM32	2716 EPROM Board A&T	$295.00	$280.00
BHDULEPROM64	2732 EPROM Board A&T	$295.00	$280.00

REAL TIME & DATA AQUISITION

SIO4/DMA INTELLIGENT CONTROLLER

4 port RS232 interface with DMA transfers for output. 256b FIFO input buffer; On board 8085A-2 processor; 16 program selectable baud rates and occupies only 16 I/O addresses. Ideal for DUAL UNIX® or other multi-user systems. **NEW!**

BHDULSIO4DMA	Assembled & Tested	$695.00	$650.00

AIM 12-12 BIT A/D CONVERTER

A/D input module with 12 bit accuracy, 32 input channels and optional instrumentation amplifier

BHDULAIM12	A&T with Instrumentation Amp.	$745.00
BHDULAIM12B	A&T without Instrumentation Amp.	$660.00

AOM 12-12 BIT D/A CONVERTER

D/A output module, 4 channels, 12 bit accuracy. Optional VIC420 industrial output module (4-20Ma), 4 channels, used in conjunction with AOM 12.

BHDULAOM12	Assembled & Tested	$675.00	$640.00
BHDULVIC420	Assembled & Tested	$675.00	$640.00

CLK24-NONVOLATILE CLOCK/CALENDAR

Day, date, hours, minutes, seconds, and 3-5 year battery backup on board. Read or write directly from I/O port. Jumperable for 64Hz UNIX® or real time applications.

BHDULCLK24C	A&T w/64Hz Interrupt	$300.00	$285.00

SALE SOFTWARE SALE

DIGITAL RESEARCH

BHDIRCPM	CP/M® 2.2 Control Program/ Microcomputers	$150.00
BHDIRMAC	MAC* Macro Assembler	$ 90.00
BHDIRRMAC	RMAC* Relocating MAC	$200.00
BHDIRSID	SID* Symbolic Instruction Debugger	$100.00
BHDIRTEX	TEX* Text Formatter	$100.00
BHDIRDES	DESPOOL* Background Print Utility	$ 50.00
BHDIRC680	CBASIC* Programming Language	$150.00
BHDIRC686	CBASIC-86* Programming Language	$325.00

*Trademark of Digital Research

MICROPRO INTERNATIONAL

BHMOSWOSTR	Wordstar Version* 3.0	$249.00
BHMOSMLMRG	Mail Merge*	$100.00
BHMOSSPSTR	Spell Star*	$150.00
BHMOSCALSTR	Calc Star*	$200.00
BHMOSDATSTR	Data Star*	$200.00
BHMOSSUPSET	Supersort*	$150.00

*Trademark of Micropro International

SORCIM

BHSORSCAL	SUPERCALC* a Superior Electronic Worksheet	$229.00
BHSORACTI	ACT I* 8080/Z80 Assembler	$175.00
BHSORACTII	ACT II* 8086/8088 Assembler	$175.00
BHSORTRNS	TRANS* 8086/8088 Translator	$125.00
BHSORPM80	PASCAL/M* REL4 8080/8085/Z-80	$395.00
BHSORPM86	PASCAL/M* 8086	$495.00

*Trademark of Sorcim

MICROSOFT

BHMOSBAS80	BASIC-80* Version 5.X Extended Disk Basic	$300.00
BHMCPBASC	BASIC* Compiler Version 5.X	$395.00
BHMOSMFT	FORTRAN-80*	$500.00

*Trademark of MicrosoftConsumer Products





110V 60Hz CVT Mainframes, the best money can buy!
12 Slot ±8V 17±16V @2A
22 Slot±8V @ 30A± 16V @ 4A

PART NO.	DESCRIPTION	LIST PRICE	SALE
BHTEIMCS112	12 Slot Desk	$755.00	$620.00
BHTEIMCS122	22 Slot Desk	$910.00	$745.00
BHTEIRM12	12 Slot Rackmount	$800.00	$655.00
BHTEIRM22	22 Slot Rackmount	$965.00	$790.00

Shipping Weight: On 12 Slot Mainframes: 45 lbs. On 22 Slot Mainframes: 55 lbs.

S-100 MAINFRAME WITH 12 SLOT MOTHERBOARD AND CUTOUTS FOR 3 - 5¼" FLOPPY DISK DRIVES

+8V @ 17A ±16V @ 2A +12V @ 1.2A Internal Power Cable

BHTEITF12	12 Slot desk	$745.00	$605.00
BHTEIRF12	12 Slot Rackmount	$855.00	$695.00

Shipping Weight: On 12 Slot Desk: 40 lbs. On 12 Slot Rackmount: 45 lbs.

DUAL 8" DISK DRIVE CHASSIS

For two Shugart 801R or two Qume DT-8 size drives with internal power cables provided +24V @ 1.5A +5V @ 1.0A - 5V @ .25A

BHTEIDFDD	Desk Top	$565.00	$480.00
BHTEIRFDD	Rackmount	$725.00	$650.00

Shipping Weight: On Desk Top: 40 lbs. On Rackmount: 45 lbs.

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SMARTMODEM

● Auto Answer, Auto Dial, Full or Half-Duplex, Loop Back© Serial binary, and asynchronous data formats with 7 or 8 data bits; 1 or 2 stop bits; odd, even or no parity ● 0-300 bauad ● RS232C interface ● Z8 Microprocessor with 2Kb control program ● 40 charactercommand buffer ● Size: 1.5" x 5.5" x 9.6".

BHDCH0200P	Smartmodem (Sh. Wt. 6 lbs.)	$279.00	$225.00
BHDCH0300P	Chronograph (Sh. Wt. 3 lbs.)	$249.00	$205.00
BHDCH0100P	Micromodem 100 (Sh. Wt. 4 lbs.)	$399.00	$325.00
BHDCH2901D	CP/M® 8" Terminal Program for above		$ 25.00
BHDCH0000P	Micromodem II	$379.00	$299.00
BHDCH2401D	Datacom (PASCAL patch) for above		$ 50.00

TeleVideo

WORLD'S BEST SELLING TERMINAL!

Extra Memory Pages! FREE!!

BHPDBTLV9252P* $749.00
*TeleVideo 925 w/free 2nd page memory kit, a $95.00 value!

BHPDBTLV9504P* $949.00
*TeleVideo 950 w/free 2nd, 3rd & 4th page memory kit, $285.00 value

BHTLV910 Sh. Wt. 43 lbs. $599.00

BEST BUY!





SEND $1.00 TODAY FOR THE NEW, FULL COLOR SPRING 1982 ENGINEERING SELECTION GUIDE!



ONE

SBC MASTER PROCESSOR

This is absolutely the most complete single board computer available; **NO EXTERNAL INTERFACE BOARDS ARE NEEDED!**
● Z80A CPU ● 64K BankSwitchable Memory ● 4K EPROM ● Auto Boot ● NEC 765 FDC with PLL interface to all Shugart compatible drives (5¼" or 8") ● 2 RS-232C Serial ports (Z80ASIO, up to 19.2K Baud) ● 2 Parallel Ports (Z80APIO) ● 4 Timers (Z80ACTC) ● IEEE 696/S-100 Compatible ● CP/M® and TURBODOS® compatible ● Full One Year Warranty

BHPOBSBCCPM	A&T w/BIOS & CP/M®2.2	$1095.00	$895.00

SBC SLAVE PROCESSOR

Similar to above with 16K EPROM, X-Buss Expansion Interface, and optional on board EPROM burner

BHSDSSBCS	Assembled & Tested	$795.00	$750.00

SDS MICROPOLIS HARD DISK INTERFACE

Micropolis 1220/1250 MICRODISK series interface adapter with software drivers, cabling, and mounting hardware. (A&T Sh. Wt. 50 lbs)

BHSDSHDI	Assembled & Tested	$150.00

MICROPOLIS 12531 45MB 8" WINCHESTER DISK

8" 3 platter MICRODISK with 36Mb formatted capacity. Drive is shock mounted in attractive Micropolis desk top enclosure with power supply.

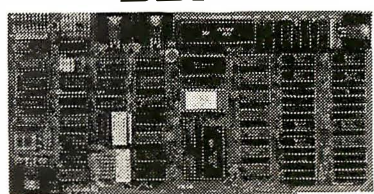
BHMCP12531	Assembled & Tested	$5384.00	$3995.00

SIERRA/MICROPOLIS SBC PACKAGE

Sierra SBC, CP/M®, Micropolis Interface, and Micropolis 12531 MICRODISK.

BHPOBSBCSYS1	(Sh. Wt. 50 lbs.)	$6629.00	$4495.00





VIDEO AND I/O

VB 3 - HIGH RESOLUTION VIDEO

80 x 25 or 50 character video display Memory Mapped, Parallel Keyboard port

BHSSMVB3A24	80 x 24 A&T	$499.00	$440.00
BHSSMVB3UP	80 x 50 Line Upgrade		$ 39.00

I/O 4

Two serial I/O, two parallel I/O

BHSSMI04A	Assembled & Tested	$290.00	$260.00

NEW! I/O 5

2 Serial, 3 parallel Including 1 Centronics

BHSSMI051	Assembled & Tested	$329.00	$309.00

NEW! I/O 8

8 Port Serial I/O with Timer

BHSSMI06A	Assembled & Tested	$550.00	$495.00

CPU, RAM & PROM

CB2 Z80 CPU

2/4 MHz will accept 2716, or 2732, or RAM

BHSSMCB2A	Assembled & Tested	$299.00	$275.00
BHSSMZ80M	SSM Z80 Monitor		$ 89.00

MB10A 16/8K 8/16 BIT STATIC RAM

16K byte /8K word, 24 bit extended, addressing, "M write," Phantom disable, addressable in 4K blocks

BHSSMMB10A	Assembled & Tested	$299.00	$275.00

MB8A 1K/16K EPROM BOARD

1K/16K 2708 EPROM board, disable in 1K increments

BHSSMMB8AA	Assembled & Tested	$179.00	$159.00

PB1 PROM PROGRAMMER

Programs 2708 or 2716's, operates as a 4K/8K EPROM BOARD AS WELL

BHSSMPB1A	Assembled & Tested	$265.00	$220.00

PRIORITY ONE ELECTRONICS







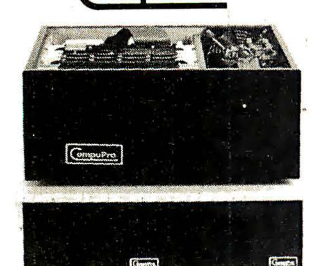
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Terms. U.S. VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6½% Sales Tax. MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $3.00 for the first 3 lbs. plus 25¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, please include your phone number. Prices subject to change without notice. We will do our best to maintain prices through August, 1982. Credit Card orders will be charged appropriate freight. If you haven't received your Spring '82 Engineering Selection Guide, send $1.00 for your copy today!. Sale prices are for prepaid orders only.

Circle 333 on inquiry card.



PERFORMANCE, QUALITY, RELIABILITY, HIGH PERFORMANCE SYSTEMS DESIGNED TO EXPAND WITH YOUR NEEDS

Al CompuPro systems have been designed with your future in mind. Each system is expandable so you can upgrade your system as your needs continue to grow. Single user systems may be upgraded into multi-user systems for under $3,000.00. Additional users may be added to multi-user systemsat any time. Hard disk storage is also availablewith the new DISK 2 DMA Winchester disk controller. Unlike many "personal" computers, your CompuPro system will not become obsolete when it is time to expand. The modular design of the IEEE 696/S-100 bus allows you to plug in additional boards when they are needed. CompuPro system components feature the latest state-of-the-art technology to prevent obsolescence.

Each CompuPro system component is fully assembled and tested under rigorous burn-in conditions at the facdtory and then shipped to *Priority One Electronics*, your authorized CompuPro Systems Center, for final integration and configuration. CompuPro systems carry the best warranty in the business; 1 year on A & T systems, 2 years on CSC systems. The Oume drives have a full six month warranty; the best drive warranty anywhere. The components are integrated into a complete system by a factory trained *Priority One Electronics* technician. The systems are then partially disassembled for shiping. After a short time for unpacking and check-out, your CompuPro system will be ready to load and go!

SYSTEM COMPONENTS

Each CompuPro system includes the following:

- CPU 8085/88 6MHz Dual Processor CPU (8088 runs at 8MHz in CSC systems
- Disk 1 Lightning Fast DMA Floppy Disk Controller
- CP/M® 2.2 and CP/M 86™ Operating Systems
- Sorcim's SUPERCALC-86 Electronic Sreadsheet program
- Two double-sided, double-density Oume DT-8 disk drives in an attractive desk top enclosure
- Rugged Desk Enclosure 2 with 20 slot actively terminated motherboard, fan, air and line filters, and constant voltage power supply for years of reliable operation
- Internal I/O cables and floppy disk data cable
- Complete documentation for each system component as well as a system integration guide

060ENTRY LEVEL SINGLE-USER SYSTEM — The system is designed for high performance at a minimal cost. It may be upgraded at any time by additional memory. Each system includes the common components listed above *and* the following:

- 128K 10MHz Low Power Static Ram for low power consumption and reliability
- Interfacer 4 I/O board with three RS232 Serial ports, one bi-directional parallel port, and one Centronics parallel port

BHGBTSYS1DKA	Single User System Desk Top, A&T	**$5495.00**
BHGBTSYS1DKC	Single User System Desk Top, CSC	**$5995.00**

SINGLE USER M-DRIVE SYSTEM — This system may be operated with CP/M® 2.2 in 8 bit mode as a 128K M-Drive system or in 16 bit mode with CP/M 86™ to give the user maximum flexibility. This system includes the common components listed above *and*:

- 192K 10MHz Low Power Static RAM for low power consumption and reliability
- System Support 1 Multifunction Board
- Interfacer 3 Eight port RS232 Serial Interface Board
- M-Drive Software for use in 8 bit mode

BHGBTSYS2DKA	M-Drive System Desk Top, A&T	**$6995.00**
BHGBTSYS2DKC	M-Drive System Desk Top, CSC	**$7745.00**

ENTRY LEVEL MULTI-USER SYSTEM — This system is designed for two or three users depending upon user memory allocation size. This system includes everything in the above **Single-User M-Drive System** *plus*:

- 8MHz 8088 standard on Dual Processor CPU board
- 192Kb of additional memory for a total of 384Kb of low power 10MHz static memory
- MP/M (816) Multi-user software. MP/M (816) is a CompuPro proprietary implementation of Digital Research's MP/M 86™ 16 bit multi-user operating system. This software package includes CP/M® V2.2, CP/M86™, and MP/M 86™. The beauty of this software is that both 8 bit CP/M® 2.2 and 16 bit CP/M 86™ programs may be run on the system at the same time by different users. This allows the user to take advantage of the vast library of 8 bit software as well as the growing selection of 16 bit software without being limited to one or the other. When running CP/M® 2.2 programs under MP/M (816) there is 60K of user memory rather than the usual 48K for better system performance; another CompuPro exclusive! This unique software package, ideal for software development or scientific applications, is available only as part of a CompuPro system.

BHGBTSYS3DKA	Multi-User System Desk Top, A&T	**$8995.00**
BHGBTSYS3DKC	Multi-User System Desk Top, CSC	**$9945.00**

Rack mount systems are also available; please call or write for details. All CompuPro systems are shipped via motor or air freight collect; please specify at time of order. All boards are shipped in standard configurations

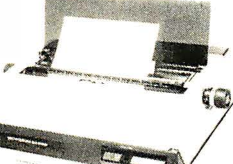
CP/M, CP/M 86, and MP/M 86 are trademarks of Digital Research. MP/M (816), a proprietary implementation of MP/M 86, is a trademark of CompuPro under license from Digital Research. (816) is a trademak of CompuPro.

5" DISKETTES!



SOFT SECTOR
40 TRACK SINGLE SIDED DOUBLE DENSITY WITH HUB REINFORCING RINGS
PKG. OF 10 $19.95

BONUS!
FREE! KASSETTE 10 LIBRARY CASE WITH PACKAGE OF 10 DISKETTES
A $4.25 VALUE Part No. BHPRI5SDD



PRI580	package of 80 less Library Case	**$120.00**
PRIBSD	package of 10 8" S.S./D.D. Diskettes no sleeves	**$20.00**
5 or more packages		**$18.00**

SMITH-CORONA TP-1

LETTER QUALITY - ELECTRONIC TEXT PRINTER



$649.00
SCMTP1510

- 12 CPS • 10 CPI • 6LPI • SERIAL INTERFACE
- 50-19.2K Baud • Friction Feed • 88 Character

BHSCM12625	TP1	Black Milar Ribbon	**$3.50**
BHSCM12658	TP1	Black Fabric Ribbon	**$7.50**

SANYO

FCC CLASS 2 APPROVED DATA DISPLAY MONITORS



SPECIFICATIONS:

Viewing Screen	12" diagonal; 75 square inches DM2112: P31 phosphor
Scanning System	525 lines; 60 fields/second; overscan
Horizontal Resolution	600 lines, center
Signal Input	1.0 volt p-p composite video; 75 ohms

BHSYODM2112

List Price: $160.00 **$SALE: $119.00**

OTHER SANYO MONITORS ON SALE TOO!!

Part No.	Description	List Price	SALE
BHSYOVM4509	9"B&W P4, 10MHz (15 lbs.)	$215.00	**$149.00**
BHSYODM4509CX	9"Green, P31, 10MHz (15 lbs.)	$200.00	**$159.00**
BHSYODM8012C	12"B&W P4, 18MHz (24 lbs.)	$250.00	**$195.00**
BHSYODM8112CS	12"GReen, P31, 18MHz (24 lbs.)	$260.00	**$199.00**
BHSYOVMC6013	13"Color, 16 x 64 (35 lbs.)	$470.00	**$375.00**
BHSYODM6113*	13"RGB Color (35 lbs.)	$995.00	**$895.00**

**As used with IBM P.C.*

APPLE DISK DRIVES



Give your APPLE II® a Fourth Dimension — the totally compatible 5¼" drive that takes your system farther, faster. With read/write electronics so advanced that reading errors are virtually eliminated. With a track zero microswitch that keeps boot and track access smooth and quiet. With the ability to read half-track software and up to 143,360 bytes on DOS 3.3®. With similar performance on DOS 3.2.1®, Pascal® or CP/M® operating systems. And, the disk enclosure mates perfectly with APPLE cabinetry.

EXTENDED WARRANTY

Fourth Dimension offers a 12 month parts and labor warranty at no cost to you! (Gee, this really looks good!)

BHFDS40A List Price: $419.00 **SALE: $369.00**

2 or More, only $350.00 each

BHFDS40AC* APPLE II® Disk Drive Controller **$115.00**

**Sold only with purchase of Fourth Dimension Drive*

HOW CLEAN IS YOUR POWER?





The Sola Micro/Mini Computer Ultra Isolated Regulator provides instantaneous voltage regulation, and ultra isolation from both transverse and common mode noise for any type of load. It also suppresses transients, protects against overloads and serves as a portable dedicated line. It is the ultimate in AC line conditioning equipment.

The Sola "Micro/Mini" is particularly applicable in systems involving mini or micro computers, POS equipment, microprocessors, or data terminals — where noise and transients cause errors, or low voltage and short term disruptions can result in loss of memory. The output waveshape is sinusoidal and contains less than 3% harmonic distortion, making it ideal for any electronic load.

Common mode noise rejection exceeds 120 dB for the regulator, while transverse noise rejection is better than 60 dB — true ultra isolation. Brownout protection is a real bonus feature. Input line voltage variations as great as ±15% are instantaneously regulated to a maximum output deviation of ±3%. And, the output will remain within NEMA voltage specifications for input voltages as low as 65% of nominal.

Especially designed for office type environments, the Sola "Micro/Mini" is truly portable and has a low sound level of 43 dB.

- Instantaneous regulation
- Regulator common mode noise rejection of 120 dB
- Regulator transverse mode noise rejection of 60 dB
- Completely portable — no installation costs
- Matches Micro/Mini computer packaging
- Complete isolation from pwer line - less than 3pFd
- Quiet operation — below normal office levels
- Operating range from -20°C to +50°C
- No loss of output for line loss up to 3 msec
- Line cord
- On-off switch
- Dual output receptacles

MINICOMPUTER REGULATORS

PORTABLE 120VAC 60 Hz SINGLE PHASE

Part No.	Maximum Output VA Rating	Dimensions L x W x D (Approx.)	Approx. Shipping Weight	Price List	Price Our
BHSLA6313070	70	12 x 6 x 6	10 lbs.	$186.85	**$159.00**
BHSLA6313114	140	12 x 6 x 6	18	$244.90	**$208.40**
BHSLA6313250	250	14 x 8 x 8	31	$291.00	**$248.05**
BHSLA6313150	500	17 x 9 x 9	47	$404.20	**$344.00**
BHSLA6313175	750	17 x 9 x 9	60	$515.60	**$438.80**
BHSLA6313210	1000	17 x 9 x 9	75	$597.20	**$508.25**
BHSLA6313220	2000*	17 x 11 x 11	108	$1015.60	**$864.35**

Output voltage is 120VAC ±3% for an input voltage of 95-130VAC
*Unit has 30 Amp twist receptacle.
Also available are Hard Wired and 50Hz Models.

MINI UPS

A mini UPS goes one stepfurtherthan a minicomoputerregulator. It provides the same voltage, noise and brownout protection plus maintains power to keep equipment running smoothly during a blackout. When a power failure occurs, the internal maintenance free battery continues powering the inverter without the use of any switching devices. This provides uninterrupted, conditioned AC power to the critical load.

A true UPS always between the AC line and critical load providing complete protection from brownouts and blackouts as well as line noise and transients. Output waveshape is sinusoidal with less than 3% single harmonic and 5% total harmonic distortion. Regulated output is ±3% when operating from either AC line or battery. Handles load surges and fault clearing providing 125% overload for 10 minutes, 150% overload for 10 cycles and 200% in short circuit with 2 automatic restrikes before shutdown. Maintenance-free battery automatically rechareages upon return of AC line. Oper. Temp. 0°C to 40°C. Especially designed for small, sensitive electronic equipment such as minicomputers, dataterminals, P.O.S. systems. Inplut voltage, 115VAC.

PORTABLE 120VAC 60Hz UNINTERRUPTABLE POWER SYSTEMS

Part No.	Maximum Output VA Rating /Time	Dimensions L x W x D (Approx.)	Approx. Shipping Weight	Price List	Price Ours
BHSLA260050400300	400/10Min	12x19x11	85	$1544.00	**$1314.00**
BHSLA260050480301	400/20Min	12x19x11	95	$1574.00	**$1339.00**
BHSLA260050750300	750/10Min	12x19x11	125	$1674.00	**$1425.00**

Also available are 220V 50Hz models of the above.

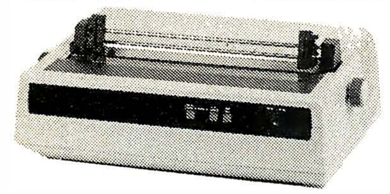
Call for all SOLA products not listed.

Circle 334 on inquiry card.

SUMMER CASH AND CARRY SALE

FUJITSU FROM SELLUM

LETTER QUALITY PRINTERS



Speed and Unmatched Performance

Interfaces: • RS232C and Current Loop • Centronics type parallel interface • IEEE/488 All are DIP switch selectable.
PersonalityProtocols: • NEC5510 • DIABLO630 • QUME Sprint9 • IBM Personal Computer • ATARI (Centronics 737).
Special Features: • Z80 CPU • 12K ROM • Standard 16K Buffer • Optional 48K Buffer • 50 - 19.2K baud • Micro-coded alarm differentiates error conditions with pulse combinations • Intelligent bi-directional printing with logic seeking • Complete word processing features • Self test • Auto reprint • Auto clear error • Proportional spacing • Supports Automatic justification • Complete Vector plotting routines • Sheet feeder mode allows easy interface to most mechanical sheet feeders • 6 month warrantee • Quiet - 60db • Front panel forms control • Universal power supply 115/220V 50/60 Hz.

BEST BUY! 80 Characters per Second! LETTER QUALITY! USING THE FUJITSU SP830 **WOW!**

Part No.	Description	List Price	Our Price
BHSLMF88	Intelligent Printer	$3495.00	$2795.00
	OPTIONS		
BHSLMF86VFT	Vertical forms tractor		$200.00
BHSLMF8848K*	48K RAM buffer		$300.00

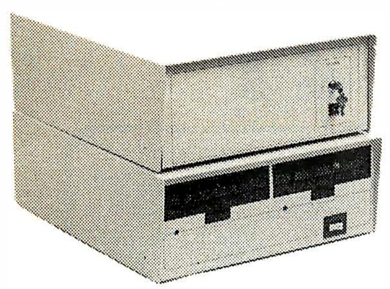
Call for pricing on sheet feed options
*Must be ordered with the printer

INTERFACE CABLES

BHCPAM572	Centronics IBM/NEC Cable	$80.00
BHSCDB251	RS232C Serial Cable	$80.00

Call for other cables not listed

Para Dynamics



18 SLOT S-100 MAINFRAME

CVT Power Supply, forced air cooling; security lock
120 or 220V AC at 50 or 60Hz+8V@20A, ±16@3.5

BHPDN20180	Desk Top	$799.00	$699.00
BHPDN201BR	Rack Mount	$849.00	$749.00

8 SLOT S-100 MAINFRAME WITH CUTOUTS FOR 2 5¼" DISK DRIVES

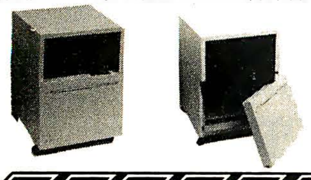
+5@5A, -5@500MA, +8@15A, +12@6A, +16@2, -16@2

BHPDN250BD	Desk Top	$899.00	$789.00
BHPDN2508R	Rack Mount	$949.00	$639.00

DISK DRIVE FACILITY

Accommodates two 8" floppy drives, of Shugart, Qume, or similar design and dimensions. 110 or 220V AC at 50 or 60Hz CVT power.

BHPDN22000	Desk Top	$659.00	$579.00
BHPDN2200R	Rack Mount	$679.00	$595.00



PRONTO

Free standing cabinet. Will accept 2, 8" Floppydisks and 1, 8" Rigid disk. 18 slot card cage will accept the double height 10" x 10" S-100 cards(Alpha Micro and others) CVT Power Supply.
+24@7A, +16@2.2A, -16@3.5A, +8@20A, +5@5A

BHPDN2818	PRONTO	$1295.00	$1129.00

PRONTO COMPLETE WITH POWER SUPPLY POWER-UP SEQUENCER

BHPDN2818S	with sequencer	$1395.00	$1249.00

Shipped motor freight collect

FREE TRACTOR AND FREE OKIGRAPH!!

OKIDATA



COMPARE OKIDATA'S FEATURES TO ANY OTHER PRINTER! COMPARE PRIORITY ONE'S PRICES TO ANY — THEN DECIDE!

Don't be fooled by those who try to "soak" you for the options

- BI-DIRECTIONAL-120 CPS
- 9 x 9 Matrix (Alphanumeric)
- 6x9or12 Matrix for graphics
- 5,8.3, 10, 16 Characters Per Inch
- 80 CPL @ 10 CPI for 82A
- 132 CPL @ 100CPI for 83A & 84
- Both Parallel and 1200 baud Serial I/O (82A & 83A)
- Self Test
- Out of Paper Switch
- Friction or Optional Tractor Feed (Tractor Standard on 84)
- 10 different character sets

All three printers feature front panel switch selectable for lengths; 10 lengths from 3" to 14". Front or bottom aper loading for up to 4 part forms and tear bar. All of these features make OKIDATA the best value in low cost printers!

Part No.	Description	List Price	SALE
BHPDBOKI82ATG	OKIDAT82A w/tractor and graphics		$539.00
BHPDBOKIB3ATG	OKIDAT83A w/tractor & graphics		$750.00
BHOKISER2KBF	9600 Baud 2K serial buffer/interface		$149.00
BHOKIDAT84AP	132 col. printer parallel interface with graphics and tractor (35 lbs.)		$ 1095.00
BHOKIDAT84AS	132 col. printer 9600 baud serial 2K interface, graphics and tractor (35 lbs)		$ 1250.00
BHMBSAPLWTWC*	Apple Parallel Interface w/Cable		$ 75.00

*Sold only with printer

COMPARE PRICES!!

ADDS
Applied Digital Data Systems Inc.



VIEWPOINT — ADDS

Detachable keyboard, RS232 interface and auxiliary port, 80 x 24 display, tiltable screen.

BHADDVWPR	Sh. weight: 30 lbs.	$699.00	$525.00

DISK CABINETS

V-100 - VISTA

• Desk or rack mountable • Internal power and data cables • Drives pull out for easy service and maintenance

BHVISVIDD	Disk Drive Cabinet (43 lbs)	$495.00	$449.00
BHVISV100	With purchase of two 8" Disk Diives		$399.00

SINGLE 8" - Q.T.

Single 8" cabinet with power supply

BHQTCDDCB	(22 lbs.)	$249.00	$225.00

DUAL 8" - Q.T.

Dual 8" cabinet with power supply

BHQTCDDC88	(24 lbs.)	$395.00	$349.00

5" CABINETS - VISTA

BHVIS9BDI	Single 5" with P.S.	$ 85.00
BHVIS9B02	Dual 5" with P.S.	$110.00

SEND $1.00 TODAY FOR THE NEW, FULL COLOR SPRING 1982 ENGINEERING SELECTION GUIDE!

Tandon



Tandon TM-800 Thinline is exactly half the size of conventional 8" floppy disk drives.

Exactly one-half the height of any other model.
Proprietary, high-resolution, read-write heads patented by Tandon
D.C. only operation - no A.C. required
Industry standard interface.
Three millisecond track-to-track access time (9 lbs.)

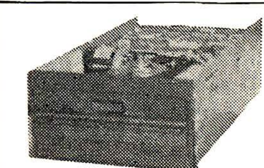
BHTNDTM8481	Single Sided	$380.00	2 or more	$370.00
BHTNDTM84B2	Double Sided	$495.00	2 or more	$485.00
BHTNDTM8M	Manual - not included with drive			$ 10.00

TANDON 5¼" DRIVES

BHTNDTM1001	Single Sided, 250KB (5 lbs.)	$220.00 * ea
	2 or More $200.00	
BHTNDTM10C2	Double Sided, 500KB	$295.00 ea.
	2 or More $270.00	
BHTNDTM1003	Single Sided, 500KB	$295.00 ea.
	2 or More $270.00	
BHTNDTM1004	Double Sided, 1000KB	$395.00 ea.
	2 or More $375.00	
BHTNDTM5M	manual, not included with drive	$ 10.00

*As used in the IBM P.C.

MITSUBISHI ELECTRIC



Better Than QUME! Better Than SHUGART!

8", Double-sided, double-density, interchangeable with QUME & Shugart

BHMITM289463	Sh. Weight 16 lbs.	$495.00
BHMITM289463 M	Manual	$ 10.00

2 or More $475.00 each

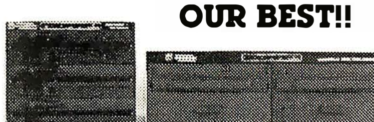
Shugart 801R

Single sided, double density - most popular 8" drive

BHSHU801R	$394.90 ea. or 2 or more (16 lbs) for	$389.90
BHSHUSAB01RM	Manual for 801R drives	$ 10.00

INTERNATIONAL INSTRUMENTATION, INC.

OUR BEST!!



UNIVERSAL DISK ENCLOSURES

• Accepts any combination of 8" drives (QUME/Shugart 801R type or ½ size Tandon type) • Also accepts hard disks • Positive pressure • Optional Disk environment monitor shows supply voltage and internal cabinet temperature • Internal power and data cables provided.

UNIVERSAL DRIVE CABINET complete with power supply, fan and filter, and all internal cables for attachment of two 8" floppy drives.

BHIIIUDE004	Dual Drive Cabinet (Sh. Wt. 40 lbs)	$495.00	$450.00
BHIIIUDE004	With purchase of two 8" Disk Drives		$399.00
BHIIIUDE004EM	w/Environmental Monitor installed	$584.95	$535.00
BHIIIUDE004EM	With purchase of two 8" Disk Drives		$485.00
BHIIIUDE004AUG	Dual Drive cabinet with Augmentation power supply module to increase 5V supply from 6 amps to 9 amps for use with two hard disks or 4 Tandon drives. Also includes Disk Environment Monitor (45 lbs.)	$733.00	$650.00
BHIIIUDERCK	19" Rack Mount kit UDE004		$ 69.95

THIN THREE DRIVE CABINET complete with power supply, and all internal cables for attachment of three thin 8" floppy drives (Tankdon type). One AC power connector is also provided for use with full size drive.

BHIIIUDETT	Three Drive Cabinet (Sh. Wt. 35 lbs)	$495.00	$450.00
BHIIIUDETTTEM	with Environmental Monitor installed	$584.95	$535.00





VISA — master charge

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PRIORITY ONE ELECTRONICS

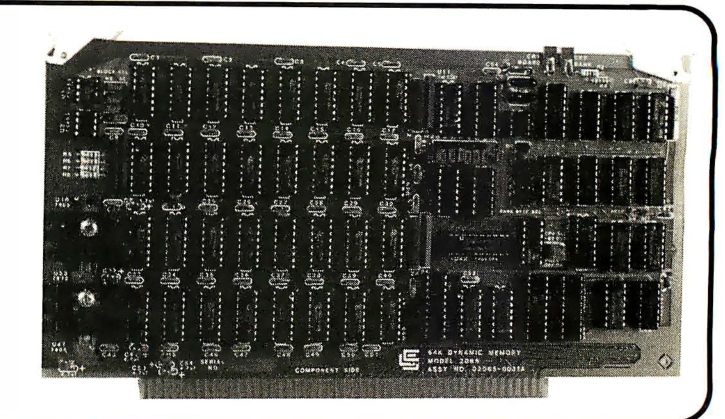
SPECIAL PURCHASES!

1 ONE



California Computer Systems

64K IEEE-S100 DYNAMIC MEMORY CARD



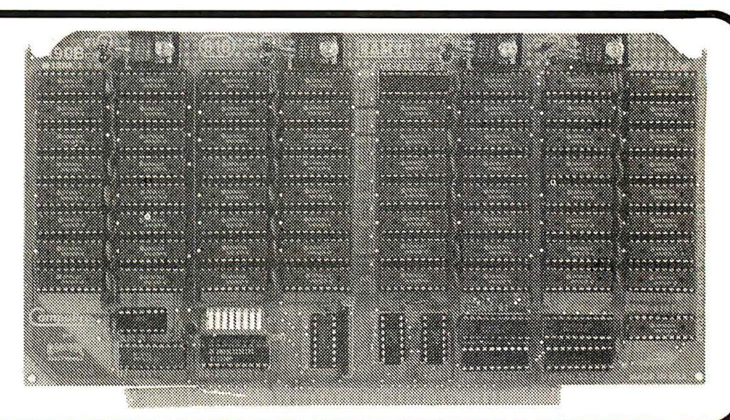
- 2 or 4 MHz operation
- Designed to IEEE proposed S-100 bus standards
- Supports IMSAI-type front panels
- Operates with either an 8080 or Z-80 based S-100 system providing processor-transparent refreshes with both
- Bank-select system allows system memory expansion
- Bank-select port's address is jumper selectable
- Any 16K block can be made bank-independent
- All 64K can be made bank-enabled on power-on and reset
- Fully buffered address and data lines
- Configuration as a 16K, 32K, or 48K board without the removal of RAMs
- Fail-safe refresh circuitry for extended Wait. States
- Board configuration with reliable easy-to-configure Berg jumpers
- Supports DMA
- Jumper-selectable Phantom inplut
- Uses Popular 4116 RAMs
- Assembled & tested
- All ICs in sockets
- Full Factory Warranty

BHCCS20653
SHIPPING WEIGHT 2 lbs.
LIST PRICE: $350.00
SAVE $130.00!!

$249.00 ea or 4/$880.00

CompuPro SYSTEMS RAM 21

128K 12MHz S-100 STATIC MEMORY 8 OR 16 BIT



The days of "Out of Memory" are gone a t last! CompuPro has introduced the largest static S-100 IEEE/696 RAM board ever to be produced.

The RAM 21 is arranged either as a 128K x 8 bit wide or 64K x 16 bit wide board, using a high speed, ultra low low power proprietary static RAM. CompuPro has also included 24 bit addressing for up to 16 megabyte capability and power consumption so low your mainframe will never know it's there!

- Meets or exceeds all IEEE 696/S-100 specifications
- Fully static design uses less power than dynamics (1.2 amps typical)
- 24 bit extended addressing
- 8 bit (128K) or 16 bit (64K) operation
- Addressable as one block
- 16K window deselect, dip switch selectable
- Switch selectable PHANTOM disable
- 12 MHz CPU operation
- 16K x 1 static RAM
- Thorough bypassing of all supply lines
- Capable of DMA processing
- 128K Static, 1.2 amps
- NMOS high speed low power memory ICS

BHGBT190A
List Price: $1695.00

SALE PRICE:

816

$995.00

SAVE $700.00!!

Circle 335 on inquiry card.

SUMMER CASH AND CARRY SALE







NEW 4½ DIGIT HANDHELDS!

The FLUKE 8060A and 8062A offer the most powerful combination of capabilities ever in a handheld DMM, including these:

- 4½ digit resolution • 10 V, 10mA, 10M sensitivity
- 100KHz True RMA (8060A) • 30KHz True RMS (8062A)
- Relative Reference • Constant current diode test
- Self diagnostics • Basic DC accuracy of 0.04% (8060A); 0.05% (8062A)

The 8060A also offers dBm, relative dB, frequency measurements to 200KHz, Autoranging megohms to 300k , and conductance (2000 nS).

BHFLUB060A	with safety designed test leads	**$349.00**
BHFLU8062A	with safety designed test leads	**$279.00**

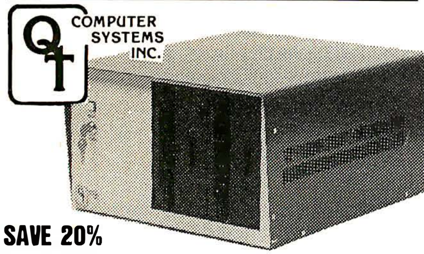
3½ DIGIT HANDHELDS: THE WORLD STANDARD

11 functions:

- dc voltage
- ac voltage
- dc current
- ac current
- resistance
- diode test
- conductance
- high-speed continuity beeper
- temperature (via K-type thermocouple
- peak hold on voltage and current functions 0.1% basic dc accuracy (8024B & 8020B) 0.25% basic dc accuracy (8021B & 8022B)
- visual logic level detection and continuity indicators

Extensive overload 3½-digit resolution protection with 600V double-fused current input. Safety-designed test leads. Two-year parts and Two-year labor warranty. Calibration Cycle.

BHFLUB024B	(All 11 functions)	**$239.00**
BHFLUB020B	(First 8 functions)	**$189.00**
BHFLUB021B	(First 7 functions)	**$149.00**
BHFLUB022B	(First 6 functions)	**$139.00**



SAVE 20%
S-100 MAINFRAMES FOR DUAL 8″ HARD AND FLOPPY DISKS

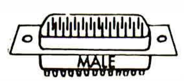
The Q.T. MFDD series mainframe is designed to be the most versatile and the most compact system enclosure on the market today. In addition to a 6, 8, or 12 slot S-100 card cage, the mainframe is designed to support two 8″ floppy or hard disk drives. It is ideal for the new generation of Single Board Computers and high density RAM cards that do not require many slots. Now you can have a complete dual floppy or hard disk system in one convenient enclosure at a remarkably low price.

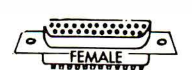
FEATURES:

- Accommodates any combination of standard 8″ floppy or hard disk drive (801 R, DT8, Fujitsu hard disk, etc.)
- IEEE S-100 Silence+ 6, 8, or 12 slot motherboard available for quiet operation with high speed processors.
- Keyed power Switch
- Reset Switch on Front Panel
- Anodized 6, 8, or 12 slot card cages
- Quiet fan with filter provides cool clean systems operation featuring positive air pressure
- Detachable line cord plugs directly into EMI noise filter for electrical noise suppression
- Two AC convenience outlets on rear panel for peripherals
- 15-DB25 cut outs for mounting I/O connectors
- 2-50 pin plug cut outs
- Dimensions: 9⅝″ x 17″ x 21″ (HxWxD) (Sh. Wt. 48 lbs.)
- Power Supply: +5V@7A, +24V@7A, +8@ 18A, ±16@3A, -5@1A

Part No.	Description	List Price	SALE Price
BHQTCMFDD	without Motherboard	$600.00	**$480.00**
BHQTCMFDD6	with 6 slot Motherboard	$675.00	**$540.00**
BHQTCMFDD8	with 8 slot Motherboard	$700.00	**$560.00**
BHQTCMFDD12	with 12 slot Motherboard	$750.00	**$600.00**

RS232 and "D" SUB-MINIATURE CONNECTORS





SOLDER TYPE

P=Plug, Male Type — S=Socket, Female Type — C=Cover, Hood

PART NO.	DESCRIPTION	PRICE 1-9	10-24	25-99
BHCNODE9P	9 Pin Male	$ 2.10	$ 1.90	$1.70
BHCNODE9S	9 Pin Female	$ 2.70	$ 2.40	$2.10
BHCNODE9C	9 Pin Cover	$ 1.50	$ 1.25	$1.10
BHCNODA15P	15 Pin Female	$ 2.75	$ 2.45	$2.15
BHCNODA15S	15 Pin Female	$ 3.95	$ 3.60	$3.20
BHCNODA15C	15 Pin Cover	$ 1.50	$ 1.30	$1.10
BHCNODA25P	*25 Pin Male*	**$ 3.00**	**$ 2.75**	**$2.25**
BHCNODA25S	*25 Pin Female*	**$ 4.00**	**$ 3.75**	**$3.00**
BHCNODB51212	1 Pc. Grey Hood	$ 1.60	$ 1.45	$1.30
BHCNO025H	2 Pc. Grey Hood	$ 1.50	$ 1.25	$1.10
BHCNODB51226	2 Pc. Black Hood	$ 1.90	$ 1.65	$1.45
BHCNODC37P	37 Pin Male	$ 5.80	$ 5.10	$4.45
BHCNODC37S	37 Pin Female	$ B.70	$ 7.70	$6.70
BHCNODC37C	37 Pin Cover	$ 1.80	$ 1.55	$1.30
BHCNODD50P	50 Pin Male	$ B.75	$ 7.75	$6.70
BHCNODD50S	50 Pin Female	$11.65	$10.25	$8.90
BHCNO0050C	50 Pin Cover	$ 2.00	$ 1.80	$1.60
BHCNO02041B	Hardware Set 2/Pr RS232, DB25P, EIA	$ 1.00	$ .B0	$ .70
BHCNORS232BF	Class 1 Cable 8 Con 8 Ft	$19.95	$17.95	$15.95
BHCNO573036	Cent. 700 Series/ Epson Printer Conn.	$ 9.00	$ 7.50	$6.00
BHIDC5730860	IDC Version of Above	$ 9.95	$ 9.00	$8.00

IBM

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IBM* PC PROTOTYPING BOARDS

	Description	1-5	6-24	25′
BHVCT4613	3 Hole Solder Board	$59.00	$53.10	$47.20
BHVCT4613-1	Bare Board	$37.00	$33.30	$29.60
BHVCT4613-2	Wire Wrapping Board	$59.00	$53.10	$47.20
BHVCT3690-22	Extender	$22.35	$20.12	

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Part No.	Description	List Price	SALE
BHPRNSTAR	RS232, TTl, 20Ma Current Loop	$199.00	**$127.00**

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MICROCOMPUTER PRODUCTS

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PART NO.	PRICE
BH4116AC20	8/$16.00
BH2016P3	B/$72.00
BH2114N3L	B/$28.00
BH5257N3L	8/$50.00
BH2732	B/$96.00
BH2716	B/$48.00
BH270B	B/$20.00

Z80 SERIES

BHZ80A	$13.39
BHZ8DAP10	$11.19
BHZB0ACTC	$11.19
BHZ80ADMA	$33.39
BHZB0AS100	$39.95
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UARTS

BHAY51013A	$5.95
BHTR1602B	$4.95
BHTR1863	$6.95
BHIM6402	$7.95

8080 SERIES

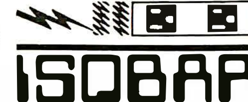
PART NO.	PRICE
BHINS80B0A	$5.50
BHINS8085A	$19.95
BHDP8212N	$2.95
BHDPB214N	$5.25
BHDP8216N	$2.95
BHDPB224N	$3.25
BHDPB224-4N	$9.95
BHDP8226N	$3.50
BHDP8228N	$5.55
BHDP8238N	$5.55
BHINSB250N	$15.95
BHINS8251N	$7.50
BHINS8253N	$17.95
BHINS8255N	$6.80
BHINSB257N	$16.45
BHINS8259N	$18.00
BHINS8259N	$59.95
BHINS8275N	$59.95
BHINS8279N	$24.95

FLOPPY DISC CONTROLLER

BHFD1771B-01	$24.95
BHFD1791B-01	$44.95

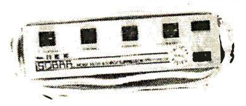
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ISOBAR

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ISOLATES SENSITIVE AND VALUABLE EQUIPMENT FROM: Equipment interaction - Damaging High Voltage Spikes - AC line noise and hash.
PROTECTS AGAINST: Voltage transients caused by lightning, contact switching, turn-off of inductive components, noise due to electro-magnetic coupling.
USE THE GSC ISOBAR TO ISOLATE: Microprocessor from peripherals - Lab instruments from noisy equipment - Sensitive pre-amp or tape deck from power amplifier.
THE GSC ISOBAR ELIMANATES: Equipment interaction - Equipment damage from power line spikes and surges - Errors - False printouts - Disk Skips - Audio or video hash
FEATURES: Inductive isolated ground - Sockets indivdually filter isolated - Circuit breaker protected at 15A.
VOLTAGE TRANSIENT SPIKE PROTECTION: 2000 A peak for up to6 Sec duration spikes. 1000A, 8/20 Sec protection from repeated spikes.
LOAD HANDLING: 1875 W max. total load; 15A per socket.
INPUT: 125 VAC, 15 amps; standard 3-prong plug.

IBAR 3 - Three common outlets built-in circuit breaker, pilot light, hang-up bracket and a 6-foot cord.

		List Price	Our Price
BHGOFIBAR3	Sh. Wt. 3 lbs.	$59.95	**$42.00**

IBAR 46 - Four independently isolated outlets. Built-in 15A circuit breaker, pilot light, switch, and 6-foot cord.

BHGOFIBAR46	Sh. Wt. 4 lbs.	$79.95	**$49.95**

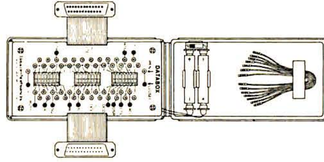
IBAR B6 - 8 outlets, grouped to form 4 independently isolated sets of two. Built-in 15A circuit breaker, on/off switch, pilot light.

BHGOFIBAR86	Sh. Wt. 5 lbs.	$84.95	**$54.95**

IBAR 9RM - Eight rear-mounted outlets grouped to form four independently isolated sets of two, plus one non-isolated convenience outlet on front face. 19″ rack mount cabinet. Built-in 15A circuit breaker, pilot light, on/off switch, and 6-foot cord.

BHGOFIBAR9RM	Sh. Wt. 6 lbs.	$99.95	**$74.95**

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Circle 335 on inquiry card.

Unclassified Ads

WANTED: Software that will run on Cromemco 5-inch single-density systems. Need an RS-232C terminal for myself, less than $500 please. I am also interested in any projects that use Cromemco's A/D-D/A board. John Hirst, POB 801, College Branch, TN 37115.

TRADE: Teledisk Model 2020 floppy-disk system with serial and modem ports to be used for data storage and entry at a remote terminal. Consider trades for 1200 bps modems, terminals, and the following Apple II cards: 80-column, Z80 SoftCard, 16 K RAM, serial, or SSM AIO. Mike Cariveau, C.E.D., POB J, Osseo, MN 55369, (612) 425-2181.

WANTED: The schematic for a Novation Model DC 101 A3 modem. Herbert Aldrich, 19 Churchill Dr., New Hyde Park, NY 11040.

FOR SALE: Two Alpha-Micro computer systems, each with double 8-inch floppy disks, four I/O serial ports and memory for four users, AM-100, AM-200, and AM-300. $3500. Has Vector S-100 bus with 18 slots. Desire trade for LSI-11 system. Russell N. Cassel, 717 3rd Ave., Chula Vista, CA 92010, (714) 420-2764.

FOR TRADE: Public-domain software for Apple II and Sorcerer. Mrs. V. Mancuso, 25/2 Brown St., Newtown, 2042 Australia.

WANTED: To correspond with those interested in using microcomputers in Bible translation. Desire help in developing programs in BASIC or Pascal to manage culture files and dictionary, as well as word processing. I am especially interested in corresponding with someone who has used an Osborne 1. Russell Reed, 84260 North Enterprise Rd., Pleasant Hill, OR 97401.

WANTED: Historic common stock price data for equity research project. Will share results with contributors. Robert W. Slemmer, 550 East Fourth St., Cincinnati, OH 45202, (513) 579-1000 or 231-1000.

FOR SALE: North Star Horizon computer 56K, SOROC IQ-120 terminal, NEC Spinwriter printer Model 5510, double-density double-disk drive, and system software. Excellent condition, used very little. $4000. John Vanderwoude, 2626 North Semoran Blvd., Winter Park, FL 32792, (305) 671-3700.

WANTED: High school student needs surplus, used, or damaged computers and related equipment. Will pay shipping costs. Richard Thompson, 127 West 19th St., McMinnville, OR 97128.

FOR SALE OR TRADE: GRI keyboard with 10 keys in case with parallel interface. Used one year and is in excellent shape. Vector Graphic Flashwriter: 16 by 64, S-100 video, works fine. Sell keyboard for $75 and video board for $125, or both for $175. I pay shipping. David Getz, 13317 Broadmeade Ave., Round Rock, TX 78664.

FOR SALE: GE Terminet 300 letter-quality ASCII terminal. 110, 150, and 300 bps, uppercase and lowercase, RS-232 interface, extra ribbons, friction and tractor feeds, and service manual. Only $480. Harold Wood, 2002 Rookwood Rd., Silver Spring, MD 20910, (301) 589-4171.

FOR SALE: Jade IOI-1046 S-100 I/O board. Works fine with IEEE-696 Z80 processor, but not with CCS 2810A. Will ship anywhere in the world for $160, postage included. Rolf Aalberg, Riislokka 58, 1600 Fredrikstad, Norway.

FOR SALE: SwTPC CT-82 terminal, SwTPC 6800 computer, three 4K cards, GIMIX 16K card, AC-30 tape I/O, Exatron Stringy/Floppy/dual, SwTPC PR-40 printer and I/O, Wintek 6800 processor card, TSC 6800 software, Computer Aid 3M3 data cartridge recorder—never used, and miscellaneous extras. Items in storage: used, functional, and clean. $1000 takes all or offer. Please send SASE. A. N. Hicks II, POB 4508, Santa Clara, CA 95054.

FOR SALE: Digital Group peripherals. Three 8K static-memory boards at $65 each (or all three for $150). Phi-Decks (4 + 1 spare), cabinet, cable, and controller card (in working order) for $300. Graph-2 (Graphic-256) graphics board, partly assembled, for $195. Carl Bignell, 600 Western Ave., Socorro, NM 87801.

FOR SALE: S-100 boards: Polymorphic VTI video interface, 64 by 16, graphics, keyboard port; $125. BYTE 8080A processor; $60. Vector Graphic 1702A PROM/RAM board with 1K RAM; $50. Vector Graphic monitor PROM for Poly VTI and 8080 on three 1702As; $30. Godbout 18-slot motherboard with seven connectors; $35. 12-inch green P3 video monitor; $50. Modular Devices power supply, regulated, OV, OC, MP, etc., +15 V @ 14 A, +5 V @ 16.5 A, −15 V @ 2 A, voltages can be changed; $80. All working. Bob Kitzberger, 7668 Saratoga Rd., Cleveland, OH 44130, (216) 234-6441.

FOR SALE: Complete set of BYTE through August 1979 (plus December 1979, January 1980, and January 1981. Kilobaud Microcomputing from January 1977 to December 1980. 80 Microcomputing from January 1980 to December 1980. Personal Computing No. 1, October, November, and December 1980, and January to April 1981. Best offer for all (or sets) within 30 days after this issue of BYTE comes out. J. C. Madsen, POB 2005, Fresno, CA 93718.

WANTED: Software that will graphically display vortex rings in 3-D. Vortex motion is like a smoke ring that moves circularly and curls as it moves. T. Johnson, Devonshire B-3, Mankato, MN 56001.

FOR SALE: Percom data separator; $20. 3G light pen for Model I. Plugs into processor or expansion interface. No battery needed. Plus software. $20. First cashier's check takes either one. John Ratzlaff, Mount Pisgah Academy, Candler, NC 28715.

FOR SALE: XTEL (RCA 141) 75 bps printer and Xerox I copier. Both new. Immediate sublease or direct sale on west coast only. Maintenance subcontract as is. Hanna, 5235 Toluca Court, Santa Barbara, CA 93111, (805) 967-1640.

WANTED: Contributions of computers, software, or whatever. Community Action Agency has been hard-hit by federal cuts and wants to computerize to better use existing funds to help poor and elderly. Will gladly accept any donations (tax deductible—we are a recognized nonprofit organization). Will work with manufacturers or dealers in testing, applications, etc. All letters answered. John R. Armstrong, Resource Coordinator, Springfield & Sangamon County Community Action Inc., 1101 South 15th St., Springfield, IL 62703, (217) 788-0757.

WANTED: To correspond with users of Thinker Toys keyed-up 8080 processor and Speakeasy I/O boards. Would like to swap hardware/software modifications and information. G. Seweryniak, 12 Kathy Dr., Poquoson, VA 23662, (804) 868-7682.

BUY SWAP SELL: Back issues of BYTE to complete my collection. Paul Gray, 780 West Main, Platteville, WI 53818.

FOR SALE: Back copies of BYTE from 1977 and 1978. 2 pounds each. K. Roche, 20 Stocker Close, Basingstoke, Hants, England.

SOFTWARE HELP: I will, at no charge, help solve your software problems. All programs will be written on an Apple II 48K 3.3 DOS system. I have three years of programming experience. I am most interested in solving high-resolution graphics problems. Scott Ayers, 432 Derby Lane, Montgomery, AL 36109.

FOR SALE: 36 issues of BYTE (December 1977 through November 1980) in good condition. Highest bid takes them; I'll pay shipping. Joe Wrobel, 233 El Mar Dr., Rochester, NY 14616.

FOR SALE: 32 K North Star memory boards with 100 hours use. Great buy at $400 for reliable board. Money-back guarantee. Marcia, (404) 367-9191 after 5 p.m.

FOR SALE: NEWDOS Plus for TRS-80. 40-track version with original documentation. $40 ppd. TRS-80 and Other Mysteries. $14 ppd. Also have many back issues of various computing magazines to trade. SASE gets current list or send your list along. Mel Mauck, 16 Edmondson Ave., Lexington, VA 24450.

FOR SALE: Two Siemens FD-100 floppy-disk drives with power supplies and cabinets. $300 each. One TI-59 programmable calculator. $135. R. Abbott, 414 Jackson Ave., Cape Canaveral, FL 32920.

FOR SALE: Due to TI-770 to 771 terminal conversion, the following TI computer parts are available in as-new condition: magnetic tape cartridge transport assembly and control board; main memory and memory-expansion board. Best offer. Edwin Langberg, 107 Fairway Terrace, Mt. Laurel, NJ 08054, (609) 778-0850 work, 983-8572 home.

FOR SALE: Exatron Stringy/Floppy with software; $200 or best offer. Radio Shack direct connect modem; $100 or best offer. Jeff Madura, 2629 Covington St., West Lafayette, IN 47906, (317) 463-5218.

FOR SALE: S-100 bare circuit boards. SSM CB1A 8080 processor board, SSM VB2 video board, and Vector VCT8800V prototyping board. Manuals and many ICs and sockets included. $50 takes all. M. Ingebretson, 247 Carolann St., Eyota, MN 55934, (507) 545-2931.

FOR SALE: Digital Group Z80 with 64K. Audio cassette board. 20 parallel ports. Dual Phi-Deck tape drives. Full ASCII keyboard. Sanyo 9-inch monitor. Phimon 2.0, Business BASIC, assembler, disassembler, and much more software. Complete documentation. A postcard gets full details. $2500 or best offer. Mel Hagen, 109 11th St. SE, Altoona, IA 50009, (515) 967-6362.

FOR SALE: Cromemco Z-2H computer with 10-megabyte hard disk, 64K RAM, two double-sided minifloppy-disk drives, 4-MHz Z80 processor, two serial and two parallel I/O ports, 12-slot chassis, power supply (30 A @ 8 V and 15 A @ ±15 V), and a rack-mountable case. Also, CP/M-compatible operating system and other software. $5000 or best offer. D. Schreiter, 5301 Old Baumgartner Rd., St. Louis, MO 63129, (314) 773-0196.

FOR SALE: Shugart Model 850 8-inch floppy-disk drives: soft-sectored, IBM-compatible, double-sided, double-density. Unused. $1050/pair. Dick Worban, (312) 735-2606.

FOR SALE: All brand new and unused. Unopened with original guarantees. Apple: Visicalc (retail $200), $140; Visifile (retail $250), $172; Visitrend/Visiplot (retail $260), $181. Take all three and I'll pay shipping and reduce the total price by $25. Desktop Plan II (retail $200), $140; Visidex (retail $200), $139.65; Visiplot (retail $180), $127; Visiterm (retail $150), $118. Take all seven and I'll pay shipping and reduce the total by $40. Visicalc (for Atari 800 or Commodore 2001, retail $200), $139.80. D. Solomon, 208 Overbrook, Freehold, NJ 07728.

WANTED: Programs, experiments, interfacing projects, games, etc., applicable to the Heathkit ET-3400 microcomputer trainer not already included in the EE-3401 home-study course. Charles Miller, Electronics Dept., Anne Arundel Community College, Arnold, MD 21012.

UNCLASSIFIED POLICY: Readers who are soliciting or giving advice, or who have equipment to buy, sell or swap should send in a clearly typed notice to that effect. To be considered for publication, an advertisement must be clearly noncommercial, typed double spaced on plain white paper, contain 75 words or less, and include complete name and address information.

These notices are free of charge and will be printed one time only on a space available basis. Notices can be accepted from individuals or bona fide computer users clubs only. We can engage in no correspondence on these and your confirmation of placement is appearance in an issue of BYTE.

Please note that it may take three or four months for an ad to appear in the magazine.

Unclassified Ads

FOR SALE: Ohio Scientific hardware. C2-8P with 20K (500, 520, 540 boards). Has 8-slot backplane, 32 by 64 display, separate keyboard, and RS-232C. Also, two 527 24K 2 MHz memory boards and 470 disk controller (new). Original prices were $999 for C2-8P, $450 for each memory board, and $100 for the disk controller. Make an offer for some or all. Mike Bassman, 39-65 52 St., Woodside, NY 11377, (212) 639-3530 evenings.

WANTED: To get in touch with North Star users in the Reading, Allentown, and Harrisburg area. George Schemel, S.J., Jesuit Center, Box 223, Wernersville, PA 19565, (215) 678-3886.

FOR SALE: CB1A 8080 microcomputer with 1K RAM, 2K ROM monitor, and keyboard port. $100. 104 two parallel and two serial ports. $90. Both boards are for S-100 systems, come with complete documentation, and work well. Steve Moore, 2541 Chestnut Court, Visalia, CA 93277, (209) 734-3969 after 6 p.m.

FOR SALE: Percom disk controller board and cable (for SS-50). $125. Two SA-400 disk drives. $225 each. Above as a package deal, $550. Tim Tibbott, 1812F Woodmar Dr., Houghton, MI 49931, (906) 482-8806.

WANTED: A Dutronics Z80 board for a Processor Technology SOL-20 computer. The board and documentation are preferred, but I will accept just the documentation. Will pay a reasonable price. Rich Obermeyer, 2025 Hall, Santa Ana, CA 92704, (714) 730-2567 days.

FOR SALE: Two used IMSAI VDP-80. Both are in excellent physical condition. One operates, one does not. $3750 or best offer. D. M. Sandler, 701 South 23rd St., Arlington, VA 22202, (703) 521-7800.

FOR SALE OR TRADE: SwTPC GT-6144 graphics terminal with power supply, enclosure, and documentation. Best offer or trade for two MP-LA or equivalent parallel interfaces for SS-50 bus. William E. Summers, 11 Homesdale Ave., Southington, CT 06489, (203) 621-7001.

WANTED: Need documentation/manuals for a MITS Altair PROM programmer card #8800 PPRG-INT Rev. 0. Chris Lyons, 15620 North 24th Ave., Phoenix, AZ 85023, (602) 942-7224.

FOR SALE OR TRADE: A brand-new UDS 103 direct-connect answer modem. I will sell it or trade for an originate modem of similar type. I am also interested in software and hardware for the TI-99/4 computer and would like to correspond with other users. Ralph Fowler, 2348 Oriole Lane, South Daytona, FL 32019.

FOR SALE: Lear-Siegler terminal, Heath H-11 computer with 48K bytes of memory, two serial interfaces, parallel interface and extended arithmetic chip, and Heath H-27 dual floppy with FORTRAN and BASIC operating systems. Package price of $5000. C. A. Potter, POB 266, Warren, MI 48090, (313) 574-9273.

FOR SALE: AJ-360 acoustic modem in good shape. $100. IBM Selectric with solenoids in good shape, New York City area preferred. $300. Mike Steckman, 215 West 91 St., New York, NY 10024, (201) 457-0511.

FOR SALE: Cromemco Bytesaver; $100. Two IMSAI 1702 PROM boards, populated; $300. Associated Electronics 1702 PROM programmer; $200. IMSAI MIO; $125. Micromation disk interface; $325. Please write before sending money. J. Williams, 902 Anderson Dr., Fredericksburg, VA 22405.

HELP: Need schematics and information on International Computer Products (ICP) Digicorder dual digital cassette drive, Model #270. Stephen D. Hammack, 1618 South Highway 121, Lewisville, TX 75067, (214) 221-3425.

WANTED: SwTPC MPA or MPA2 processor board. Also, MPB motherboard. Bare boards or assembled. Roger Steedman, POB 98, Bairnsdale, 3875 Australia, (051) 568291.

FOR SALE: Alpha Micro system. AM100 with 96 K memory, PerSci 277 1.2 megabytes dual floppy drive. SOROC IQ 120 terminal with 10-key pad, and TI-810 printer with miscellaneous software utilities. Asking $5250. Jim Turner, 151 North Fourth St., Springfield, OR 97477, (503) 747-1261.

FOR SALE: Digital Group Version "A" printer (Practical Automation) with cabinet, cables, spares, and full documentation. The second to the top needle has worn out. I will provide a sample printout. 100 cps and capable of full dot graphics. Asking $100 plus shipping. Larry Langrehr, 2069 North Humboldt Blvd., Chicago, IL 60647.

FOR SALE: BYTE from June 1980 through the current issue. $30 or best offer. A. Williams, 47 Duffield Dr., South Orange, NJ 07079.

FOR SALE: 2012 A-4 static RAMs. Low power (40 mA) and fast (250 ns typical). $9.60 per set of eight chips, sockets, and decoupling caps, or $290 for all 32 K. Just buy a Wameco PC board and you're in business. Also, TI Silent 700 printer. Comes with all documentation, extra print heads, PC boards, and rolls of paper. $200 plus shipping. J.C. Hassall, PO Drawer H, Blacksburg, VA 24060, (703) 552-0599 after 5 p.m.

FOR SALE: Paper Tiger 460G printer. Barely used. With graphics. Best offer over $850. Valued over $1300. E. Siguel, POB 5, Brookline, MA 02146, (617) 739-4887.

FOR SALE: Do you need a TV camera interface? Here is a fast Video Graphic board that could do the job. Three boards make a set: A/D, DMA, and D/A. New, $900; sell for $500 or best offer. Deluxe camera also available. Dan Fellers, 2512 Maryland, Topeka, KS 66605, (913) 232-4977.

WANTED: Professional programmer to implement CP/M for a Cromemco Z2D 48 K computer. Will pay reasonable charge. Billy Pinkerton, 33 West Strawbridge Apt. E9, Melbourne, FL 32901.

BOMB

BYTE's Ongoing Monitor Box

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Team Effort Wins BOMB

Christopher P. Kocher and Michael Keith's team effort in reviewing six new entries in the microcomputer arena in "Six Personal Computers from Japan" earned them the number one spot this time. Our congratulations to these authors for their report. They will share the $100 prize. Second place goes to Steve Ciarcia for describing how to build a simple and inexpensive real-time clock in "Everyone Can Know the Real Time." He will receive $50. And Steve Leibson's fourth part of his highly successful six-part I/O series, "The BCD and Serial Interfaces," brought him a close third.

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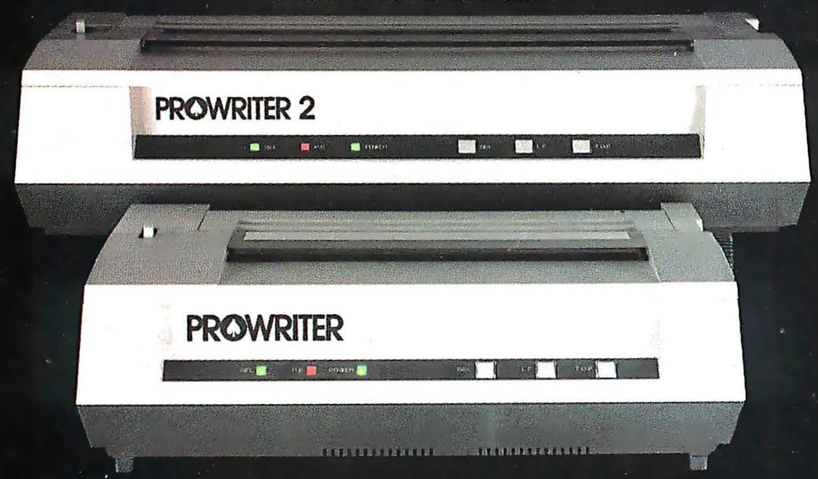
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